State of Delaware Freshwater Wetlands Inventory Pilot Project

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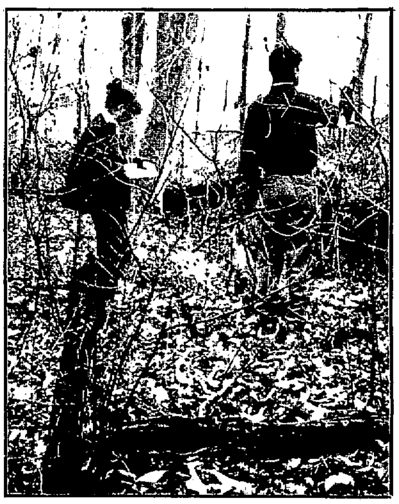

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1.0 INTRODUCTION

1.0 INTRODUCTION

Greenhorne & O'Mara, Inc. has been retained by the Delaware Department of Natural Resources and Environmental Control (DNREC) to conduct a pilot project to determine the effectiveness and cost of several approaches to the use of aerial photography and related basemaps for regional wetland mapping. The preparation of this document was financed in part through a grant from the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration, U. S. Department of Commerce, under the provisions of Section 306 of the Coastal Zone Management Act of 1972, as amended.

1.1 <u>Objectives</u>

The objectives of the pilot study are outlined below. Please note that two of the objectives were optional and were not performed.

1.1.1 Effectiveness of Classification

G&O will determine the relative effectiveness and marginal costs of using different source photography to differentiate wetland classes using both the modified Cowardin classifications and the Category I and II wetlands classifications proposed in Delaware's Freshwater Wetlands Act.

1.1.2 Production Times and Costs

G&O will determine the production time and cost associated with using a 0.25-acre minimum mapping unit at 1:6,000 scale for regulatory maps, and G&O will estimate, using existing information, production time and cost associated with using a 1.0-acre minimum mapping unit at 1:12,000 scale for guidance maps.

1.1.3 Change Detection (Optional)

The optional task of determining the effectiveness of performing change detection with multitemporal photography was not performed.

1.1.4 NWI Comparison (Optional)

The optional task of comparing the wetland acreages of the mapping produced by the pilot project and the National Wetland Inventory was not performed.

1.1.5 Photo Basemap and Data Compilation

G&O will evaluate the suitability of using rectified photo basemaps (1/16 quadrangle maps, 1:6,000 scale, produced from true color and color infrared aerial photography registered to USGS quadrangle maps) for data compilation.

1.1.6 Simple Rectification versus Ortho Rectification

G&O will measure the topographic relief for each 1/16th quad in the state to determine the amount of relief displacement for each 1/16th quad and to determine whether simple or ortho rectification are needed to produce photo basemaps that meet National Map Accuracy Standards.

1.1.7 Expected Ground Displacements

G&O will determine the average horizontal ground point displacement expected on each 1/16th quad which theoretically requires ortho rectification to meet National Map Accuracy Standards, but is rectified using simple rectification.

1.1.8 Tidal Wetland Data Transfer

G&O will determine the feasibility and production time associated with transferring existing tidal wetland limits from delineated aerial photography to 1:6,000 scale photo basemaps, for reconciling the regulatory boundaries between tidal and non-tidal wetland maps.

1.2 <u>Review</u>

The following introduction discusses the basic concepts which should be considered when determining methods and source imagery required to conduct a regional wetland inventory. It includes a discussion of delineation and cartographic accuracy, scale, delineation equipment, and data storage.

When reviewing and assessing the applicability of wetland mapping methodologies, five factors must be considered: accuracy, efficacy, scale, timeliness, and cost. Related to these factors are data storage requirements, which, although not specifically part of the actual delineation process, are an important consideration in the determination of data formats and mapping mediums.

When assessing the accuracy of wetland mapping methodologies, not only must the delineation accuracy be considered, but also the cartographic accuracy. Delineation accuracy is a function of the type of source imagery used, scale of the imagery, resolution of the imagery, stereoscopic coverage of the imagery and the medium on which the imagery is analyzed (film, paper, or computer). The ability and experience of the interpreter, the equipment used for interpretation, the basemap scale, the basemap type (e.g., topographic versus orthophoto), and the amount of field verification performed are also important.

The accuracy of a completed wetland delineation is influenced by the accuracy of the basemap it is being registered to and displayed on. The cartographic accuracy of the basemap, the accuracy with which the wetland delineation data are compiled onto the basemap, and the accuracy with which the mapped data are converted into a digital format are also important. For a description of National Map Accuracy Standards, see Appendix A.

Efficacy (the characteristics of the photographic film related to the film's ability to uniformly record conditions) must also be considered. Related to this is the time of year, time of day, and the conditions under which the remotely-sensed data are collected.

Scale plays an important role in the mapping process. Often, it is the required output scale which will determine the mapping methodology to be used. However, it should be noted that when deciding on output scale, it is really information type and density which are being considered. The scale of the source imagery will often be the limiting factor that determines the amount of raw information per unit area available to the analyst.

A complicating factor is the resolution of the imagery (spatial and spectral), which contributes to the raw information content available at a particular scale for interpretation. For example, true color and black-and-white imagery will often have almost twice the resolution of CIR imagery at the same scale because of technical limitations during data capture.

A thorough and accurate wetland delineation at a designated scale can be compromised by inaccurate data transfer, faulty conversion, and/or an inaccurate basemap. Rarely will a wetland mapping program take all these accuracy factors into consideration before the actual mapping methodology is designed and work begins.

Stereo viewing of imagery greatly facilitates discrimination of the topographic lows and depressions often associated with wetlands. It allows discrimination of micro-relief which often (especially in flat terrain such as coastal plain regions) is a strong indicator of a change in water regime. Subtle changes in slope help an interpreter designate wetland boundaries in areas where facultative hydrophytic species are persistent in upland terrain. Also, the three-dimensional spatial relationships in combination with distinctive spectral characteristics evident in stereo-viewing help identify false wetland spectral signatures, such as burn areas and areas where seral (transitory) vegetation such as black cherry temporarily dominates the landscape.

Interpretation equipment used for stereo viewing of imagery varies from inexpensive field binocular lenses (2x and 4x models) ($30-$80), to mirror stereoscopes ($1,000 - $6,000), to moderately expensive optically precise stereo zoom transfer and stereo microscope equipment ($20,000 - $30,000), to expensive stereo compilers ($150,000 - $250,000) which digitize the delineated data as the data are interpreted.

Field binocular lenses and mirror stereoscopes usually have some zoom capabilities and, when used with film transparencies, are limited by the use of traditional light tables with one intensity setting. The optical resolution and accuracy afforded by this equipment vary from poor with the field binocular lenses to fair with the mirror stereoscopes. The advantages of using this equipment are the ease of operation and low cost. Using it requires physical delineation onto a mylar film registered to the imagery. This process increases data registration error and limits delineation accuracy by the "pen width" used by the interpreter (i.e., a 0.01-inch pen width on 1:40,000-scale imagery translates to approximately 33 feet on the ground), regardless of the intended scale of the basemap.

This method of interpretation requires the transfer of delineated information to a suitable basemap for data conversion. The transfer is achieved in a number of ways. The simplest and least accurate, is a direct "eyeball" transfer by hand to a photo basemap or topographic basemap. Another technique is to use mono or stereo zoom transfer scopes to complete the transfer of the delineated data, a process which results in a more accurate cartographic product. This equipment facilitates the transfer process by superimposing the imagery onto the basemap optically, allowing a direct transfer of data. Inaccuracies associated with this technique include misregistration of photo with the basemap and inaccurate tracing of the delineation from the photo onto the basemap.

Stereo microscopes are optically very precise and, when combined with a high-intensity variable light source, provide excellent image resolution and clarity. They often come with variable magnification (up to 16x). However, they are subject to the same data transfer and "pen width" delineation accuracy limitations as the field binocular and mirror stereoscopes.

Although stereo zoom transfer scopes, even when combined with a high-intensity variable light source, do not offer as clear an image as the microscope, they are much superior in clarity, resolution, and optical precision to field binocular and mirror stereoscopes. The stereo zoom transfer scope also has the advantage of allowing a direct transfer during the interpretation of the wetland boundary data from the imagery to the basemap. Through optical registration of the photos with the basemap, the interpreter is able to map features visible on the photography, directly onto the basemap, at basemap scale, which greatly enhances the "pen width" delineation accuracy, (i.e., using 1:40,000-scale imagery and a 1:6,000-scale basemap, a 0.01-inch pen width represents 5 feet on the ground, not 33 feet as in the previous example using a mirror stereoscope).

A disadvantage of all the methods discussed so far is the need to convert the delineated wetland boundaries, now registered to a basemap, to a digital format. Hand digitizing of complex delineations (polygons and linears) is very time consuming and is prone to operator-induced error. Scan digitizing, although very accurate, requires exceedingly "clean" cartographic products as input. All polygons must close, lines may not cross over each other, line density must be consistent, and, if ink on mylar is used as the product to be scanned, labels must be on a separate sheet or in pencil and thus transparent to the scanner.

The only way to avoid the post-delineation/post-transfer digitizing step is to digitize as you delineate. This is possible only on the stereo zoom transfer scope and stereocompilation equipment. On the stereo zoom transfer scope, digitizing is accomplished by moving an interactive "mouse" over the basemap as the delineation proceeds. The disadvantage here is that for interactive edit and quality control, only the digitized linework (not the image or basemap) is shown on the computer screen. The stereocompilation equipment, however, allows for interactive delineation, digitizing, and editing with digitized linework and imagery visible to the analyst. The disadvantages are that the equipment is very expensive and extensive training is required for its proper use. The advantages include high-accuracy, one-step data analysis and conversion for use in a GIS.

The sophisticated database engine in a GIS has the ability to associate and manipulate diverse sets of spatially-referenced data which have been coded to a common geographic referencing system (geocoded). To permit this, it might be necessary, for example, to use software that transforms State plane coordinates and milepoint data to latitude/longitude. A GIS is capable of topological operations, i.e., it recognizes how elements contained in the database are related to each other spatially, and it can perform spatial manipulations on these elements. It provides efficiency and flexibility for data storage and revision over traditional hardcopy (mylar) systems.

A GIS contains two broad classifications of information, geocoded spatial data and attribute data. Geocoded spatial data define objects that have an orientation and relationship in 2- or 3-dimensional space. Each object is classified as a point, a line, or an area and is tied to a geographic coordinate system. These objects have precise definitions and are clearly related to each other according to the rules of mathematical topology.

Since a GIS permits the utilization of spatial relationships, it adds a degree of intelligence and sophistication to a resource management database that enhances analysis of the data. For example, for a riverine wetland (a line) next to a road network, a GIS system knows what routes (other lines) cross it and whether there is an actual physical intersection. It also knows the position of roadside features (points) along the wetland segment. It can also tell which wetlands (polygons) are to the right and the left of a feature or within any given distance of it.

2.0 METHODOLOGY

2.0 METHODOLOGY

This section describes the methodology used to complete the study. The following subsections are organized into functional tasks and include basemap production, wetland delineation, photointerpretation and conventions, field work, deliverables, and analysis procedures.

2.1 Photo Basemap Production

G&O produced a photo basemap for each of the selected 1/16th quad areas using aerial photography supplied by DNREC. "Mosaic" photo basemaps were created from multiple single rectifications at 1:6,000 scale. For simple rectification, aerial photograph negatives were placed in a rectifying enlarger and the image was projected onto an enlarger easel. A combined process of enlarging, tipping, and tilting was used to match the photo image with a network of control points. When a satisfactory fit of the control points was accomplished, a sensitized stable base mylar film was placed on the enlarger easel along with a half-tone screen, and the imagery was exposed on the film. The exposed film was developed in an automatic processor to produce half-tone positives. The photo basemaps were produced to National Map Accuracy Standards.

For ease in identification, the 1/16th basemaps were numbered sequentially within each USGS 7.5 minute quadrangle. Figure 1 shows this numbering system.

FIGURE 1

DELAWARE WETLANDS PILOT

NUMBERING SYSTEM FOR 1/16th BASEMAPS WITHIN USGS 7.5 MINUTE QUADRANGLES

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

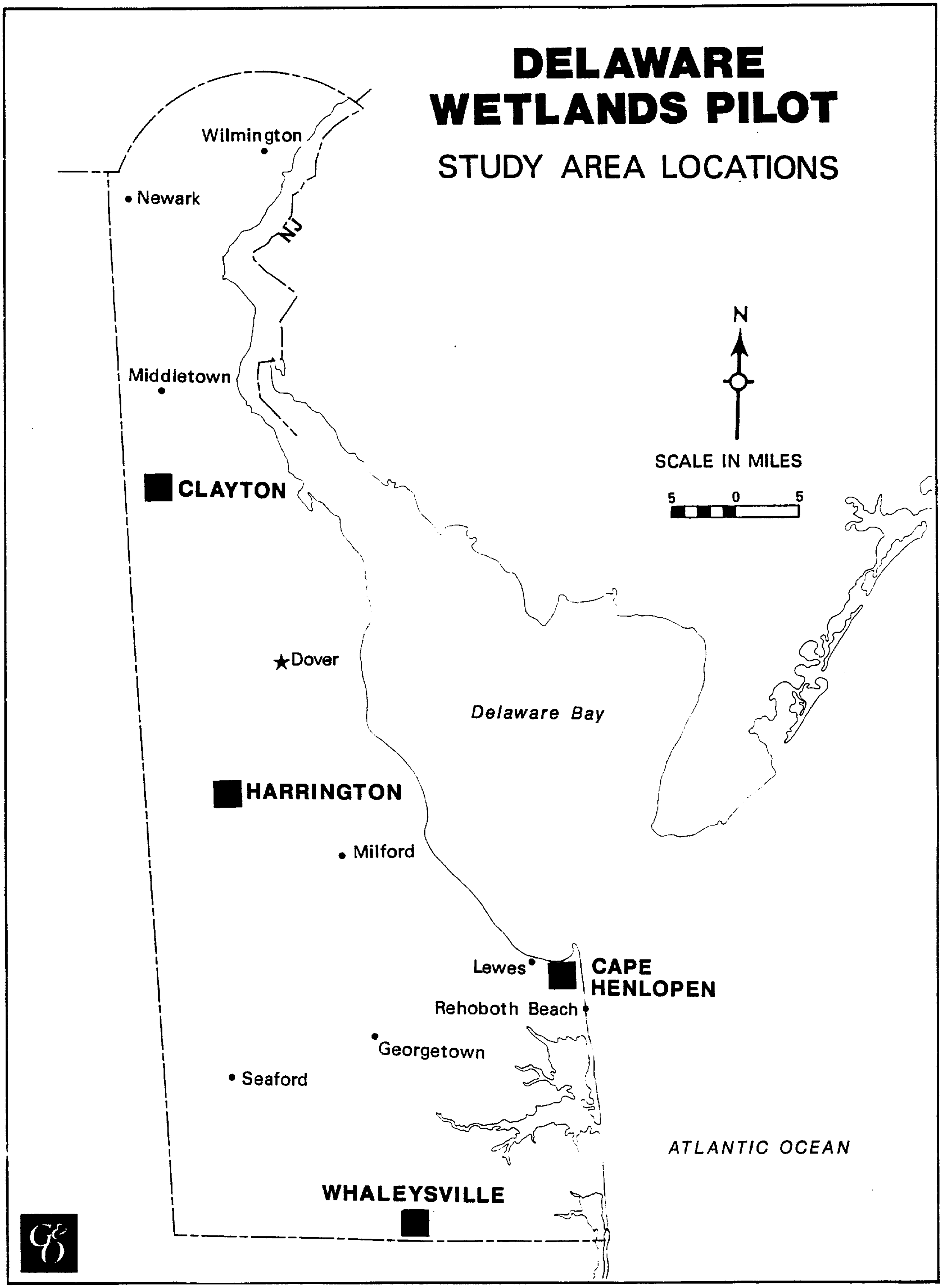
2.2 Wetland Delineation

The purpose of this pilot mapping project was to identify the extent and character of non-tidal freshwater wetlands in four different DNREC-selected 1/16th quad areas. Figure 2 shows the study area locations. The delineations were performed through stereoscopic analysis of true color and color infrared aerial photography using Bausch & Lomb Stereo Zoom Transfer Scopes (ZTS), review of existing soils, topography, NWI maps, selected relevant publications, and the collection and analysis of field data from field investigations. Copies of the soil surveys and field data sheets are included in the Appendix. Copies of the NWI maps are attached.

The photointerpretation, delineation, and document review was followed by a field investigation to verify and refine the wetland delineations and classifications. Wetlands found were not flagged or surveyed, however, their approximate locations were recorded on 1:6,000 scale photo basemaps using photointerpretation and best field judgment.

Wetlands delineations were made using the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (January, 1989), hereafter referred to as the Federal Manual. The Federal Manual generally uses a three-parameter approach, hydrophytic vegetation, hydric soils, and hydrologic indicators, to delineating wetlands. Normally, all three parameters must be present for an area to be considered a wetland under Section 404 of the Clean Water Act, as well as Section 7603 of the proposed Delaware Freshwater Wetlands Act. Exceptions to this requirement include open-water and riverine systems and disturbed areas.

FIGURE 2


DELAWARE
WETLANDS PILOT
STUDY AREA LOCATIONS
Wilmington
Newark
NJ
Middletown
CLAYTON
Dover
Delaware Bay
HARRINGTON
Milford
Lewes
CAPE
HENLOPEN
Rehoboth Beach
Georgetown
Seaford
ATLANTIC OCEAN
WHALEYSVILLE
N
SCALE IN MILES
5
0
5

Although procedures for making field determinations are outlined in the Federal Manual, judgments are sometimes required, depending on the strength or weakness of any of the three parameters. In addition, transition areas between wetlands and uplands often exist, also requiring judgments as to the boundaries.

For this mapping project, wetlands found on each 1/16th quad were classified using two different classification systems. A first set of wetland maps were delineated to identify Delaware's more unique and exceptional wetland types, including Delmarva Bays, dune swales, Atlantic white cedar, bald cypress, and wetlands with water regimes ranging from permanently flooded to flooded for extended periods during the growing season. These wetland types are included in Category 1 and Category 2 wetlands as defined in Section 7604 of the proposed Delaware Freshwater Wetlands Act.

A second set of wetland maps were produced using a modified Cowardin Classification, (<u>Classification of Wetlands and Deepwater Habitats of the United States</u>, 1979). This hierarchial system is the nationally-recognized standard for wetlands classification, and provides consistent terms and concepts to define wetlands using various biological, geological, pedological, and hydrological factors.

2.2.1 Vegetation

Plant species observed at each wetland area were identified and the wetland indicator status for each species was determined from the <u>National</u>

List of Plant Species that Occur in Wetlands: Northeast (Region 1) (May 1988). The indicator status designates the probability of occurrence (expressed as a percentage) of a given plant species in wetlands of the northeast region of the United States. The following is an explanation of the indicator status designations:

- OBL = Obligate Wetland (greater than 99% probability of occurrence)
- FACW = Facultative Wetland (greater than 66% probability of occurrence)
- FAC = Facultative (33% - 66% probability of occurrence)
- FACU = Facultative Upland (1% - less than 33% probability of occurrence)
- UPL = Obligate Upland (less than 1% probability of occurrence)
- NA = Has been reviewed, but no agreement has been reached by the Regional Interagency Review Panel as to its indicator status
- NI = No indicator status recorded; insufficient information available
- NL = Not on list; therefore, presumed to be obligate upland plant.

Generally, hydrophytic vegetation criteria for wetlands are met when more than 50 percent of the dominant plant species from all strata in the plant community has an indicator status of OBL, FACW, and/or FAC (Federal Manual).

2.2.2 Soils

Hydric soils are soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions that favor the growth and regeneration of hydrophytic vegetation (Federal Manual). A hydric soil may either be drained or undrained, although a drained hydric soil may not continue to support hydrophytic vegetation. Hydric soils may be referred to as "wetland" soils only when the hydric soils support hydrophytic vegetation and the area has indicators of wetland hydrology (Federal Manual).

During field investigations, soil borings were taken, generally to a depth of 18 inches, to determine whether or not wetland soils were present. Several soil characteristics were evaluated, including soil composition, structure, texture; hue, chroma, value; odor, and moisture. In addition, the U.S.D.A. Soil Conservation Service's County Hydric Soils List was reviewed to determine if soils were classified as hydric. The "Munsell Soil Color Charts" were to verify hydric soil hue, chroma, and value. Soils characteristics were evaluated using moistened soil samples in the absence of direct sunlight for consistency.

2.2.3 Hydrologic Indicators

Wetland hydrology encompasses the hydrologic characteristics of an area that is periodically inundated, or is saturated to the surface at some point in time during an average rainfall year as specified in the Federal Manual. Wetland hydrology indicators are useful in establishing whether a wetland is periodically inundated or has been saturated to the surface at some point in time during the year. Hydrology indicators include, but are not limited to, visual observations of surface water or soil saturation, drift lines, sediment deposition, watermarks, blackened leaves, surface scouring, and numerous plant morphological adaptations. For a detailed discussion of the criteria used during this project, see the Federal Manual. Hydrological characteristics observed at each site were noted during the field investigations.

2.2.4 Tidal versus Nontidal Limits

As stated in Section 7603 of the proposed Delaware Freshwater Wetlands Act, tidal wetlands mapped pursuant to 7 Del. C. Chapter 66 are exempt from the proposed requirement of a freshwater wetlands permit and wetland conservation buffer area. DNREC provided G&O with tidal wetland boundaries delineated on mylar overlays registered to the CIR aerial photographs (Frame Nos. 03-003, 03-005, 04-029, 04-031) for the Cape Henlopen study area.

A Bausch & Lomb Stereo Zoom Transfer Scope (ZTS) was used to transfer tidal wetland boundaries from the 1:14,000 scale CIR photography (with registered overlays) to the 1:6,000 scale photo basemaps. Use of the ZTS allowed the viewing of the CIR photography and photo basemaps simultaneously at the same scale, and allowed the direct, accurate transfer of features directly onto the photo basemap. Tidal wetland boundary inaccuracies identified during photointerpretation by the presence of non-tidal vegetation and the absence of tidal vegetation, were corrected.

2.3 Photointerpretation

Photointerpretation was performed using Bausch & Lomb Stereo Zoom Transfer Scopes (ZTS). Aerial photography was interpreted while simultaneously reviewing collateral data including: SCS soils maps and data, USGS topographic maps, NWI maps, meteorological and hydrologic data (taken prior to the photo mission); and publications on climate, vegetation, and land use.

Analysts stereoscopically interpreted true color, and false color infrared aerial photography for spatial, spectral, textural, and relational characteristics. Table 1 lists the photography used in this study. Wetlands were delineated and assigned appropriate classification labels, and sites for field checks were selected from areas with "classical" wetland and problematic signatures.

The ZTS was ideally suited for this project. Operating on the "Camera Lucida" principle, the ZTS allowed the photointerpretor to visually superimpose the photographic image, seen in stereo, over the base map. The ZTS's adjustment mechanisms allowed the photointerpretors to manipulate images to coincide with their position on the base map, allowing very accurate delineation of features onto the base map.

> The ZTS provides continuous zoom magnification of the stage image (photography) from 0.6x to 16.1x, while the base image (base map) may be viewed at magnifications of 0.7x, 1.0x, 2.0x, or 4.0x. This allows the accurate and precise matching of the photographic and base images. The ZTS also has an anamorphic correction system, which allows photointerpretors to rectify distortions in the imagery, which may result from tilt, lens distortion, topographic relief, and the earth's

TABLE 1

DATA SOURCES BY STUDY AREA

Study Area	Photography Date	Type	Approximate Mean Scale
Clayton	4/23/89	True Color	1:15,000
	3/28/82	CIR	1:58,000
Harrington	4/23/89	True Color	1:15,000
	3/28/82	CIR	1:58,000
Whaleysville	4/17/89	True Color	1:15,000
	3/28/82	CIR	1:58,000
Cape Henlopen	3/12/88	False Color IR	1:14,000
	3/28/82	CIR	1:58,000

curvature. The ZTS also allows rotation of the photographic image, to compensate for the effects of crabbing, without physically moving the photographs.

The ZTS's numerous optical and mechanical features allowed the photointerpretors to rectify and superimpose the stereo images over topographic maps, soils maps, NWI maps, and base manuscripts. Ultimately, this increased the efficiency of the wetland delineations, and allowed for accurate delineation directly onto the base map.

The ZTS's magnification capabilities easily allowed for compliance with the 0.25-acre minimum mapping unit. The area covered by the minimum mapping unit corresponds to approximately 0.1 square inches at the base map scale of 1:6,000. The ZTS allowed us to enlarge the image up 5x, readily allowing accurate identification of small features.

In general, the photointerpretation was conducted in three steps. First, the upland/wetland boundary was delineated for each watershed or sub-watershed. In all cases, the delineated line was shown entirely within the wetland polygon so that the outside edge of the line corresponded to the exact position of the upland/wetland boundary. Second, the wetlands were subdivided by water regime classifications. Third, the resultant wetlands were further subdivided by vegetation/landuse/habitat classification. Wetland polygons that were smaller than the 0.25-acre minimum mapping unit were incorporated into adjacent wetlands if they were not isolated by uplands and were not being included into a higher wetland category as described by the State's proposed wetland legislation. Isolated upland polygons, less than 0.25 acres in size, within larger wetland polygons, were incorporated into the surrounding wetland polygon.

Polygons less than 15 feet wide were mapped using a single line instead of two lines. For instance, when the width of a polygon pinched down at a particular location to less than 15 feet (but more than 5 feet), then the polygon was depicted cartographically as a single line. This was done to avoid having parallel polygon boundary lines which are so close together that it is difficult to accurately digitize and display them. When the width of a linear feature or a polygon was less than 5 feet, then it was not mapped. This was done because the pen "line-width" on the map is equivalent to 5 feet on the ground.

The Modified Cowardin Classification Maps and the Delaware Category I and II Wetland Classification Maps were produced separately. This allowed the determination of the amount of time needed to delineate both types of maps, which have different levels of complexity.

The modified Cowardin classification system was developed from the USFWS Cowardin Classification System (Cowardin, et al, 1979) with numerous additions and deletions at different classification levels. The classification key used is shown in Figure 3. Additions were made to classify "unique" and "special interest" habitats and ground covers, and to slightly increase the level of detail in the classification system.

The Marine and Estuarine systems were not used because this project was limited to mapping non-tidal, freshwater wetlands. Tidal wetland boundaries were provided by DNREC, from a recent tidal wetland mapping effort. The Riverine Tidal subsystem was retained to incorporate areas that were not mapped in the tidal mapping project.

The Lacustrine Littoral subsystem (L2) was deleted because this boundary can only be delineated by identifying the 2 meter depth contour (depth below annual low water). To be consistent with NWI mapping conventions (USFWS, Draft II, 18 Dec. 1981,p.10), "all water bodies greater than 8 hectares (20 acres) in size should be considered to be in the Limnetic subsystem unless detailed depth information is available".

Several Subclasses and Special Modifiers were added to identify areas with Atlantic White Cedar (Chamaecyparis thyoides) and/or Bald Cypress (Taxodium distichum). If these species were found covering more than 10

FIGURE 3

CLASSIFICATION KEY
MODIFIED COWARDIN CLASSIFICATION SYSTEM
DELAWARE FRESHWATER WETLANDS PILOT PROJECT

SYSTEM — R — RIVERINE

SUBSYSTEM: 1 — TIDAL; 2 — LOWER PERENNIAL; 3 — UPPER PERENNIAL; 4 — INTERMITTENT; 5 — UNKNOWN PERENNIAL

CLASS	Subclass
RB – ROCK	1 Bedrock; 2 Rubble
UB – UNCONSOLIDATED BOTTOM	1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
*SB – STREAMBED	1 Bedrock; 2 Rubble; 3 Cobble-Gravel; 4 Sand; 5 Mud; 6 Organic; 7 Vegetated
AB – AQUATIC BED	1 Algal; 2 Aquatic Moss; 3 Rooted Vascular; 4 Floating Vascular; 5 *Unknown submergent*; 6 *Unknown Surface*
RS – ROCKY SHORE	1 Bedrock; 2 Rubble
US – UNCONSOLIDATED SHORE	1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic; 5 Vegetated
**EM – EMERGENT	2 Nonpersistent
OW – *OPEN WATER/ Unknown Bottom*	

*STREAMBED is limited to TIDAL and INTERMITTENT SUBSYSTEMS, and comprises the only CLASS in the INTERMITTENT SUBSYSTEM
**EMERGENT is limited to TIDAL and LOWER PERENNIAL SUBSYSTEMS. The remaining CLASSES are found in all SUBSYSTEMS

SYSTEM — P — PALUSTRINE

CLASS	Subclass
RB – ROCK	1 Bedrock; 2 Rubble
UB – UNCONSOLIDATED BOTTOM	1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
AB – AQUATIC BED	1 Algal; 2 Aquatic Moss; 3 Rooted Vascular; 4 Floating Vascular; 5 *Unknown Submergent*; 6 *Unknown Surface*
US – UNCONSOLIDATED SHORE	1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic; 5 Vegetated
EM – EMERGENT	1 Persistent; 2 Nonpersistent
SS – SCRUB-SHRUB	1 Broad-Leaved Deciduous; 2 Needle-Leaved Deciduous; 3 Broad-Leaved Evergreen; 4 Needle-Leaved Evergreen; 5 Dead; 6 Deciduous; 7 Evergreen; 8 *Atlantic White Cedar*
FO – FORESTED	1 Broad-Leaved Deciduous; 2 Needle-Leaved Deciduous; 3 Broad-Leaved Evergreen; 4 Needle-Leaved Evergreen; 5 Dead; 6 *Deciduous*; 7 *Evergreen*; 8 *Atlantic White Cedar*
OW – OPEN WATER/ *Unknown Bottom*	

SYSTEM — L1 — LACUSTRINE (LIMNETIC)

CLASS	Subclass
RB – ROCK BOTTOM	1 Bedrock; 2 Rubble
UB – UNCONSOLIDATED BOTTOM	1 Cobble-Gravel; 2 Sand; 3 Mud; 4 Organic
AB – AQUATIC BED	1 Algal; 2 Aquatic Moss; 3 Rooted Vascular; 4 Floating Vascular; 5 *Unknown Submergent*; 6 *Unknown Surface*
OW – *OPEN WATER/ Unknown Bottom*	

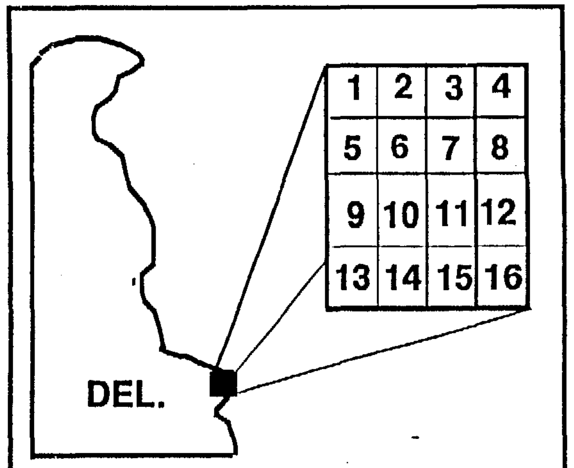
SYSTEM — HA — *WETLAND HABITAT UNITS*

SUBSYSTEM: B—*DELMARVA BAY*; S — *DUNE SWALE*

SYSTEM — MOD — *MODIFIED SYSTEMS*

SUBSYSTEM: AG – *AGRICULTURE*; D – *DISTURBED (CONSTRUCTION, ETC.)*; L – *LAWNS & MAINTAINED AREAS*; R – *RIGHT-OF-WAY*; HAB – *DELMARVA BAY*; HAS – *DUNE SWALE*

NOTE: Italicized items are modifications of the Cowardin Classification



QUADRANGLE LOCATION

MODIFIERS

In order to more adequately describe wetland and deepwater habitats one or more of the water regime or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

WATER REGIME		SPECIAL MODIFIERS	
Non-Tidal			
A Temporarily Flooded	H Permanently Flooded	b Beaver	h Diked/Impounded
B Saturated	J Intermittently Flooded	ce *Atlantic White Cedar*	r Artificial Substrata
C Seasonally Flooded	K Artificially Flooded	cy *Bald Cypress*	s Spoil
D Seasonally Flooded/ Well Drained	W Intermittently Flooded/Temporary	d Partially Drained/Ditched	sp *Special*
E Seasonally Flooded/ Saturated	Y Saturated/Semi-permanent/Seasonal	f Farmed	x Excavated
F Semipermantly Flooded	Z Intermittently Exposed/Permanent		
G Intermittently Exposed	U *Unknown*		

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July 1991

percent, but less than 30 percent of an area, then the corresponding special modifier was used to designate that polygon. If these species were found covering more than 30 percent of an area, then the appropriate subclass designation was used.

The Modified (MOD) system and Wetland Habitats (HA) system were also added. MOD System areas qualify as wetlands under either the "Disturbed Areas" or "Problem Area Wetlands" provisions of the Federal Manual. The MOD subsystems identify the specific type of human activity, including Agriculture, Construction, Fill and Excavation, Right-of-Way maintenance, Lawns and other maintained areas, and modified Wetland Habitats.

The Wetland Habitats include two unique ecosystems, identified with B- for Delmarva Bays, and S- for Dune Swales (Fig 3). The Delmarva Bay/upland or Delmarva Bay/wetland boundary surrounding a Delmarva Bay (HAB) classification was determined by using a combination of topographic relief and wetland "signature" from the aerial photography. For example, when a forested Delmarva Bay located within a larger forested wetland polygon was identified, then the first criteria used in delineating the limit of the Bay was topographic breakpoint. For example, as one moved away from the center of the Bay, and the topography increased, then the point at which the topography leveled off or started to decrease was identified as the boundary of the Bay.

The second criteria used was the presence of a wetland spectral "signature" in the area inside the break in topography. If a spectral "signature" changed from wet to upland before the break in topography was reached, then the Bay/upland boundary was delineated at that point.

A "Special Species" (sp) modifier was also added to designate those polygons in which subsequent field work confirmed the presence of special, threatened or endangered species. This modifier was not intended for use during the photointerpretation step, but was created to allow flexibility in future resource management by the State.

Field verification was conducted interactively with the photointerpretation. This allowed the photointerpretor to resolve problematic signatures and significantly increases the accuracy of the wetland delineations.

2.4 Field Work

Field sites were selected from areas with "classical" wetland and problematic spectral signatures, and were then marked on USGS topographic maps and the photo basemaps. Subsequently, site checks were made to verify the photointerpretation and revise the wetland delineations. Site check locations are shown on the maps attached to this report.

Detailed statistical sampling was not conducted to determine the classification or delineation accuracy achieved during this pilot study. During the field verification, numerous wetland boundaries were checked, and often only rough measurements were made of the mapping accuracy. Classification accuracy was determined at every site.

Site checks were performed by evaluating the three parameters of vegetation, soils, and hydrology, using the methods outlined in the Federal Manual. Vegetation can be classified as (1) obligate wetland, (2) facultative wetland, (3) facultative, or (4) facultative upland species. Sites meet the hydrophytic vegetation criterion when, under normal circumstances, more than 50 percent of the dominant species from all strata are either obligate wetland, facultative wetland, or facultative species (Federal Manual).

Soils were evaluated by sampling and examination using soil borings averaging 18 inches in depth. The U.S.D.A. Soil Conservation Service defines hydric soils as soils that are either "(1) saturated at or near the soil surface with water that is virtually lacking free oxygen for significant periods during the growing season or (2) flooded frequently (i.e. more than 50 times in 100 years) for long periods (i.e. more than 7 consecutive days) during the growing season." The soil matrix color and the color of mottles, if present, were classified using the Munsell soil color charts. Generally, sites meet the hydric soils criterion when the soil matrix has a chroma of 1, or a chroma of 2 or less with mottles within 18 inches of the surface. Several exceptions to this criterion are outlined in the Federal Manual and were used in the field when applicable.

Finally, the hydrology was evaluated. Sites meet the hydrology criterion by direct measurement of inundation and/or soil saturation or tidal flooding (Federal Manual). If inundation is not observed, wetland hydrology indicators may be used. These indicators include water marks, blackened leaves, surface scouring, drift lines, water-borne deposits of mineral or organic matter, and plant morphological features such as buttressed trunks, multiple trunks, pneumatophores, and adventitious roots.

The data obtained from the field sites are summarized in the attached data sheets in Appendix B.

2.5 Deliverables

The following final products were prepared for the State of Delaware (DNREC) in conjunction with this report:

- Four mylar photo basemaps with wetland delineations mapped using a modified Cowardin Classification System (Attached).
- Four mylar photo basemaps with wetland delineations mapped using Delaware's proposed Category 1 and Category 2 wetland classifications (Attached).
- Field data sheets documenting the ground verification of wetland delineations in the four study areas (Appendix B).
- Modified Cowardin Classification System key (Figure 2).
- Four registered mylar overlays depicting ground features that were measured to determine the resulting scale accuracy of the photo basemaps (Attached).

2.6 Analysis Techniques

2.6.1 Effectiveness of Classification

Several different types of aerial photography were used for this study. Low altitude true color photography and high altitude color infrared (CIR) photography were used for the Clayton, Harrington, and Whaleysville study areas. Low altitude false color infrared and high altitude CIR photography were used for the Cape Henlopen study area. (True color photography was not available for this area.) The different types of aerial photography used for each of these areas is listed in Table 1. Although, 1:40,000 scale CIR NAPP is available for the State of Delaware, the acquisition dates are almost all leaf-on (summer) or late April, which is not ideal for wetland delineation. An index to that photography is included in Appendix C.

Different types of aerial photography were compared during the study. The different types (and dates) of photography facilitated the assessment of the characteristics of water, soil, vegetation, and other surface features. The CIR, for example, enhanced the assessment of soil moisture because of water's relatively high absorption in the infrared. The CIR also helped with the identification of many evergreen tree and shrub species because of their unique spectral signatures. Although the true color photography used in this study provided fewer spectral indicators for photointerpretation, it was a valuable collateral data source. The leaf-off photography also facilitated distinguishing between deciduous and evergreen vegetation.

The draft delineations were initially made and refined by alternately reviewing and comparing the two different types of aerial photography, and using collateral data as needed. There was a six to seven year gap between flight dates for the two types of aerial photography for each study area. This long period of time accentuated vegetation and hydrology changes, which proved especially useful for analysis of transition areas.

The true test of the accuracy of photointerpretation was the field verification. Field verification was performed for sites with "classic" wetland and problematic spectral signatures. This helped verify and/or refine delineations, particularly areas with problematic spectral signatures.

2.6.2 Change Detection (Optional)

The task of determining the effectiveness of performing change detection with multitemporal photography was optional and was not performed.

2.6.3 NWI Comparison (Optional)

The task of comparing the wetland acreages of the pilot mapping project and the National Wetlands Inventory was optional and was not performed.

2.6.4 Photo Basemap and Data Compilation

To determine the accuracy and adequacy of the photo basemap for data compilation, the distance between distinct fixed ground points on the photo basemap and the distance between the same points on the stable base mylar USGS quad was compared. If at least 90 percent of the measurements were within 0.03 inches (16 feet on the ground), then the photo basemap met National Map Accuracy Standards.

The adequacy of the photo basemaps for data compilation is not only a function of cartographic accuracy but also of photographic clarity and ground resolution. These photo basemap characteristics were qualitatively assessed during the photointerpretation process and again during the field investigations. Most importantly, recognition of ground features at 1:6,000 scale was assessed with respect to the minimum mapping unit requirements (0.25-acre polygons and 5-foot wide linears).

2.6.5 Simple Rectification versus Ortho Rectification

Two separate procedures, <u>simple rectification</u> and <u>ortho rectification</u>, may be used to produce photo basemaps from unrectified aerial photography. The difference between the two procedures are the methods used to rectify the photography. The following discussion outlines those differences.

For simple rectification, aerial photograph negatives are placed in a rectifying enlarger and the image is projected onto an enlarger easel. A combined process of enlarging, tipping, and tilting is used to match the photo image with either a map or a network of control points accurately plotted on stable base material. Simple rectification is used whenever the ground elevation differences are so small that the resulting relief displacements do not exceed National Map Accuracy Standards[1]. This method has two major advantages over ortho rectification. First, it is less expensive, and second, the basemap resolution tends to be better since it has not been digitally scanned.

For ortho rectification, two (or more) overlapping aerial negatives are placed in a stereoplotting instrument to form a spatial model, as is done for contour mapping. Orthophoto scanning equipment exposes narrow strips of photography, throughout the stereo model, onto a film negative to produce a continuous photo image unaffected by relief displacement. Ortho rectification is used whenever the ground elevation differences and the resulting relief displacements are so large that the National Map Accuracy Standards cannot be met by simple rectification. Ortho rectification has the advantage that a digital product is produced that can be directly input into a computer system.

The Relief Displacement Formula shown in Table 2 was used to determine which rectification procedure should be used to produce 1:6,000 scale photo basemaps that meet National Map Accuracy Standards.

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[1]For maps published at scales larger than 1:20,000 not more than 10 percent of the test points shall be in error by more than one-thirtieth of an inch (0.03").

TABLE 2

RELIEF DISPLACEMENT FORMULA

$$d = \frac{rh}{H}$$

d = horizontal displacement

r = radial distance between principle point and displaced image

h = elevation difference between displaced point and principal point

H = flight altitude above principal point

Therefore: $H = \frac{f}{s}$ f = camera focal length

s = photo scale representative fraction

$$h = 0.00\overline{66} \times \frac{\text{Map scale inverse}}{2}$$

$$d = \frac{0.41\overline{66} \times h}{7000} = 0.833 \text{ (horizontal displacement)}$$

Ground elevations (contours and spot elevations) were reviewed for each 1/16th quad area in the state to determine which rectification process is required to meet National Map Accuracy Standards. Based on the flight altitude above the principle point, photo scale, camera focal length, and the 90 percent requirement of the National Map Accuracy Standards, the maximum elevation difference allowable for each 1/16 quad was 20 feet. If the elevation difference within any 1/16 quad was less than 20 feet, then simple rectification can be used to produce a photo basemap that meets National Map Accuracy Standards.

2.6.6 Expected Ground Displacements

On those maps which would theoretically require ortho rectification to meet National Map Accuracy Standards, horizontal displacements expected from using a simple rectification process were calculated using the Relief Displacement Formula (Table 2). Once the horizontal displacement constant (d) was determined, that figure (0.833) was multiplied by the maximum ground elevation difference on the map to give the maximum expected ground displacement on the photo basemap.

2.6.7 Tidal Wetland Data Transfer

Tidal wetland boundaries were obtained directly from DNREC compiled on mylar overlays registered to 1:14,000-scale CIR aerial photographs. The tidal wetland boundaries were transferred from the 1:14,000-scale aerial photographs to the 1:6,000-scale photo basemaps using a ZTS, to ensure accurate line transfer. The ZTS allowed precise superimposition of the registered tidal wetland data and photo basemap image at the same scale.

3.0 RESULTS

3.0 RESULTS

3.1 Effectiveness of Classification

In general, Color Infrared (CIR) aerial photography is regarded as being very effective for delineating wetlands. Its effectiveness is due to the absorptive quality of water in the near-infrared, which on CIR photography, accentuates areas with wet or moist soils. For example, on the Cape Henlopen study area, where low altitude CIR photography was available, areas of moist or wet soils were apparent as dark tones on the photography.

The high altitude CIR aerial photography used for this study was 1:58,000 scale NHAP photography. This CIR aerial photography was of poor quality. Although the timing of the mission was adequate, the processed photographs were overexposed within the cyan range, resulting in a strong bluish cast which effectively masked and muddied the red tones. This made it extremely difficult to distinguish between evergreen species. Also, marginally wet soils had signatures indicative of much wetter conditions. The ground resolution of the 1:58,000 scale CIR photography was much less than that of the other photography used in the study. These factors, combined with the age of the coverage, made accurate photointerpretation difficult using the NHAP CIR for 1:6,000 scale compilation and especially difficult in transition areas undergoing hydrologic change.

For this study, the true color photography was effective and was found to be of excellent photographic quality, exhibiting very good resolution, tonal, and textural characteristics. However, all of the true color photography was flown in the middle to latter part of April. This resulted in some obstruction of the ground surface since many trees began to exhibit bud swelling and leaf formation in the beginning of April. It was found that at the time this photography was collected, most Red Maple trees (<u>Acer rubrum</u>) were already forming leaves. This obscured the signatures of the trees associated with the maples. In the Whaleysville study area, for example, it proved very difficult to identify Bald Cypress (<u>Taxodium distichum</u>) when mixed with maple. Yet within the same area a small stand of pure Cypress was readily identifiable.

In very complex wetland areas showing a large amount of leaves on the trees, the true color photography did not provide the clarity and resolution necessary to accurately map the different wetland classes present. This was evident on both the Cowardin and Category I and II maps. However, because of its scale, the true color photography gave an excellent feel for topographic relationships, and a reasonable indication of hydrology especially when the ground surface was not obscured.

The results of the preliminary field measurements of delineation accuracy indicated line placement errors <u>ranging</u> from 5 to 100 feet. The <u>average</u> placement error was found to be approximately 10 to 25 feet on the ground, or .02-.05 inches on the 1:6,000 scale basemap. National Map Accuracy Standards at this scale require that 90 percent of the points on a map be within 16 feet, or .03 inches, of its exact location on the ground. Therefore, a line placement error of 16 feet or less, when measured off of the 1:6,000 scale basemap, could theoretically be correct, with the measured error being a result of basemap accuracy, not a faulty delineation.

3.2 Production Times and Costs

Projected costs associated with using the 1:15,000 scale true color photography for volume production of basemaps for the entire State are as follows:

Simple Rectification	$500 each (346)
Ortho Rectification	$800 each (286)

These figures result in a total projected cost of $401,800 to produce photo basemaps at 1:6,000 scale for the entire State. It should be noted that these costs are high when compared to industry standards, due to the fact that the source photography should have been flown at a higher altitude and quarter quad-centered for efficient production of basemaps at 1:6,000 scale. Because the true color photography used to produce the basemaps was not quarter quad-centered, numerous splices were required to "composite" the basemap image. This resulted in an expensive and less visually exact product than if higher altitude photography had been used.

The projected costs associated with the wetland delineation are outlined below. These costs do not include the production of basemaps. These costs are based on labor rates which are consistent with industry standards. The projected costs are based on producing maps similar in complexity to those studied during this pilot, but under a mass-production scenario. Estimates are also given for production of 1:12,000 scale maps (quarter-quads), using a one acre minimum mapping unit, based on prior experience producing similar products. The percentages listed below after each quad name are an estimate of the portion of the State which is covered by that specific (physiographic/ecological) quad type.

These costs do not include the conversion of the data to digital format. Conversion costs are discussed in Section 4.2.

Quad Type and Percent Coverage	Projected Cost Per 1/16 Quad		Projected Cost Per 1/4 Quad	
	Cowardin	Category 1&2	Cowardin	Category 1&2
Whaleysville (20%)	$2,400	$1,950	$3,400	$2,800
Clayton (10%)	$3,000	$2,500	$4,000	$3,300
Harrington (42%)	$1,800	$1,400	$3,000	$2,400
Cape Henlopen (28%)	$1,800	$1,400	$3,000	$2,400
Cost for Entire State	$1,288,800	$1,023,400	$502,800	$406,400

The costs shown above are slightly higher than expected due to the delineation problems encountered with the aerial photography used during this pilot. Also, the cost for the Cape Henlopen type maps includes the cost of transferring and updating the tidal wetlands data.

3.3 Adequacy of Photo Basemap for Data Compilation

Three fixed ground points were selected and measured on each 1/16th quad photo basemap produced, and the same points were found and measured on

TABLE 3

RELIEF DISPLACEMENTS ON PHOTO BASEMAPS

The location of the points identified in this table are shown on the overlays (registered to the photo basemaps) attached to this report.

		Map Feature Displacement (in.)	Actual Displacement (ft.)
Cape Henlopen			
Point A to Point B	-	.010	5.0
Point C to Point D	-	.006	3.0
Point E to Point F	-	.013	6.5
Clayton			
Point A to Point B	-	.003	1.5
Point C to Point D	-	.001	0.5
Point E to Point F	-	.006	3.0
Harrington			
Point A to Point B	-	.000	0.0
Point C to Point D	-	.007	3.5
Point E to Point F	-	.011	5.5
Whaleysville			
Point A to Point B	-	.015	7.5
Point C to Point D	-	.010	5.0
Point E to Point F	-	.002	1.0

the USGS 7.5 minute stable-base mylar quadrangle. The results are summarized in Table 3 and show that all four photo basemaps have a very high degree of cartographic accuracy and are suitable for precise data compilation. The highest displacement discrepancy found was 7.5 feet, and all displacement figures were well under the 16-foot maximum allowance.

The ground resolution of the photo basemaps was found to be very good, with individual trees and houses easily identifiable. The photo basemap scale (1:6,000, or 1 inch = 500 feet) was found to be suitable for use with the 0.25-acre minimum mapping unit.

The 0.01-inch pen width used for final delineation corresponded to a 5-foot wide line on the ground at the 1:6,000 photo basemap scale. This lineweight was found to be adequate for delineating upland/wetland boundaries using a 0.25-acre minimum mapping unit.

3.4 Simple Rectification versus Ortho Rectification

It was determined that 632 1/16th quadrangles will be required to cover the entire State of Delaware. By using the Relief Displacement Formula (Table 1), it was calculated that at 1:6,000 scale, 20 feet is the maximum ground elevation difference within a 1/16th quad allowable for use of simple rectification. Whenever the elevation difference exceeds 20 feet, ortho rectification will be needed to produce a photo basemap that meets National Map Accuracy Standards.

It was found that simple rectification will be sufficient for 346 of the 1/16th quads (54.7 percent of the total number of 1/16th quads), and that 286 quads (45.3 percent of the total) will require ortho rectification to produce photo basemaps that meet National Accuracy Standards. Appendix D1 shows the basemap name and type of rectification required for each 1/16th quad in Delaware.

3.5 Expected Ground Displacements

The 1/16th quads that require ortho rectification to meet National Map Accuracy Standards are shown in Appendix D1. The estimated displacements that would result from simple rectification on those quads that normally would require ortho rectification to meet National Standards are shown in Appendix D2.

3.6 Tidal Wetland Data Transfer

The transferred tidal wetland boundaries on the photo basemaps correspond precisely to the original tidal wetland boundaries on the mylars registered to the low-altitude CIR aerial photography. During photointerpretation of the nontidal wetlands, the tidal wetland boundaries were revised wherever boundary discrepancies were apparent from the presence of identifiable, nontidal plant species. In most cases, the revisions to the boundaries were minor.

The width of the original delineated boundaries at 1:14,000-scale corresponded to between 20 and 30 feet on the ground. The width of the transferred boundaries at 1:6,000 scale corresponded to 5 feet on the ground. As a result of the different line widths, boundary revisions exceeding 5 feet at 1:6,000-scale were common, but were often within the width of the original boundaries (20 to 30 feet) at 1:14,000 scale.

The field verification in the Cape Henlopen study area included extensive surveys of tidal wetland boundaries. In all cases, the boundary revisions were found to be accurate.

4.0 DISCUSSION and RECOMMENDATIONS

4.0 DISCUSSION AND RECOMMENDATIONS

4.1 Effectiveness of Classification

The quality, age, and to a lesser extent, the scale of the 1:58,000 scale NHAP CIR resulted in it being a poor choice for a regional wetland inventory of the State of Delaware. The 1:15,000 scale true color photography was effective because of its quality and scale, however, it was not ideal due to its lack of infra-red information and acquisition date. The problems expected if the true color photography is used for delineation include:

1) Higher delineation times and costs
2) Lower delineation accuracy (and indirect costs)
3) Increased field time and costs
4) Higher basemap production costs and lower quality

If DNREC intends to conduct a statewide wetland inventory, a new photo mission would reduce basemap production costs and improve delineation accuracy. Preferably, 1:40,000 scale CIR photography should be acquired. The mission should be conducted during mid-March to avoid leaf cover and minimize shadow effects due to low sun angles. The mission should also be quarter-quad centered utilizing north-south flight lines.

4.2 Production Times and Costs

The production costs outlined in Section 3.2 are higher than expected due to problems encountered with the aerial photography. If a new photo mission was flown, as outlined above, those costs could be reduced by as much as 10 percent due to the time saved during photointerpretation and field work. Accuracy would be increased, and as outlined below, basemap production costs would also be reduced.

Data conversion costs for use of the data in a GIS are projected to be approximately $1,000 per map sheet. This would include delivery of digital files in ARC/INFO compatible format and mylar composites of the delineation data (in white line) on the photo basemaps. The mylar composites could then be available for use with a blue-line machine for distribution to the public.

4.3 Photo Basemap Production

The cost of basemap production could be reduced by approximately 10 percent if a new photo mission is flown. The estimated cost of a CIR mission at 1:40,000 scale would be around $50,000. In combination with the projected saving expected during wetland delineation, a net resultant savings ranging from $600 to $119,000 could be realized <u>after</u> paying for the new mission.

4.4 Simple vs. Ortho Rectification

Roughly 45 percent of the 1/16th quad basemaps will require ortho rectification to meet National Map Accuracy Standards. Because during the rectification process, "Models" which include elevation and positional control must be developed covering adjacent 1/16th quads, it is cost effective to ortho rectify pairs of adjacent (east-west) 1/16th quads (within quarter quads) at a time. Given this consideration, approximately 57 additional 1/16th quads can be produced at simple rectification costs using ortho rectification. On this basis, roughly 53 percent (343 of the 632), of the 1/16th quads should be produced using ortho rectification production methods.

If digital products are required, the whole State can be produced using an ortho rectification process. Although more expensive than using a combination of simple and ortho rectification processes, subsequent scanning of the maps produced using simple rectification can ultimately be more expensive and result in a second generation product with less resolution. The extra cost of producing the remaining 47 percent of the basemaps using an ortho rectification procedure would be approximately $80,000. However, this cost could be partially or totally offset if a new photo mission is flown.

4.5 Tidal Wetland Data Transfer

The original tidal wetland boundaries were precisely transferred using the ZTS, and the boundaries were easily and accurately revised during photointerpretation. These methods are well-suited for future wetland mapping projects, and if desired, can be used to compile and revise Delaware's existing tidal wetland data.

4.6 Data Storage and Distribution

To achieve maximum flexibility, data storage should be in a format compatible with DNREC's ARC/INFO GIS. This will allow for easy revision of wetland data and access to a powerful array of analysis techniques resident in the GIS. An alternative method of data storage is the use of a traditional mylar/blueline system where maps are stored in flat files. The disadvantage of this alternative includes the possibility of misplacing individual maps, a high cost of map revision, and no data analysis. A data distribution system for the public must be reliable, cost effective, fast and provide an easy way to revise the data. If a mylar/blueline system is used, all of these requirements are met except ease of revision and data analysis capability. If a computer system is used where map sheets are plotted for the public on request, then speed, reliability, and cost-effectiveness are compromised.

Because both systems have positive and negative attributes, a hybrid system which uses a GIS to store, revise and analyze the data, but relies on a traditional mylar/blueline method of map distribution for the public appears to be the best alternative. It has the cost-effectiveness, speed and reliability of a mylar/blueline system, and the versatility and analysis capability of a computer system. The link between the two systems occurs when a map is revised in the computer. In that instance, a mylar plot of the linework is produced and a white-line composite with the photo basemap is assembled in the photolab. The new mylar is then used to replace the old mylar and blueline copies are prepared when requested by the public.

The following matrix summarizes the three techniques with respect to their ability to distribute maps to the public and their corresponding attributes.

TABLE 4

DATA DISTRIBUTION MATRIX

	Reliability	Cost Effectiveness	Speed	Ease of Revision	Data Analysis	Amount of Training	Overall Score
All Mylar	High	High	High	Low	Low	Low	Med
Hybrid System Computer/Mylar	High	High	High	High	High	Low	High
All Computer	Low	Low	Med	High	High	High	Med

5.0 COST COMPARISON SUMMARY

5.0 COST COMPARISON SUMMARY

The following matrix summarizes the projected costs outlined in the previous sections. These costs are estimates and are meant for use for planning purposes only.

STATE-WIDE WETLANDS MAPPING

(Costs are in thousands of dollars)

	Photo Acquisition	Basemap Production	Wetland Delineation	Data Conversion	Total
Existing Photography					
1/16 Cowardin	-	$401.8	$1,288.8	$632.0	$2,322.6
1/16 Category 1&2	-	$401.8	$1,023.4	$632.0	$2,057.2
1/4 Cowardin	-	$100.5	$ 502.8	$158.0	$ 761.3
1/4 Category 1&2	-	$100.5	$ 406.4	$158.0	$ 664.9
New Photography					
1/16 Cowardin	$50.0	$361.6	$1,159.9	$632.0	$2,203.5
1/16 Category 1&2	$50.0	$361.6	$ 921.1	$632.0	$1,964.7
1/4 Cowardin	$50.0	$ 90.5	$ 452.5	$158.0	$ 751.0
1/4 Category 1&2	$50.0	$ 90.5	$ 365.8	$158.0	$ 664.3

6.0 REFERENCES

6.0 REFERENCES

Cowardin, L.M., V Carter, F.C. Grolet and E.T. LaRoe. December 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife SErvice. Office of Biological Services. Washington, D.C. 47pp.

Reed, P.B., Jr. March 1988. National List of Plant Species that Occur in Wetlands: Northeast (Region 1). U.S. Fish and Wildlife SErvice Biol. Rept. 88(26.1).

Robinson, A.H., J. Morrison, and R. Sales. 1978. Elements of Cartography. Department of Geography University of Wisconsin - Madison. pp 8-10.

Tiner, Ralph W., Jr. September 1985. Wetlands of Delaware. U.S. Department of the Interior Fish and Wildlife Service, Newton Corner MA and Delaware Department of Natural Resources and Environmental Control, Wetlands Section, Dover DE. Cooperative Publication. 77 pp.

Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, D.C. Cooperative technical publication. 76 pp. plus appendices.

U.S. Department of Agriculture, Soil Conservation Service. December 1987. Hydric Soils of the United States. National Technical Committee for Hydric Soils. Washington, D.C.

U.S. Department of Agriculture, Soil Conservation Service. April 1971. Soil Survey of Kent County, Delaware.

U.S. Department of Agriculture, Soil Conservation Service. October 1970. Soil Survey of New Castle County, Delaware.

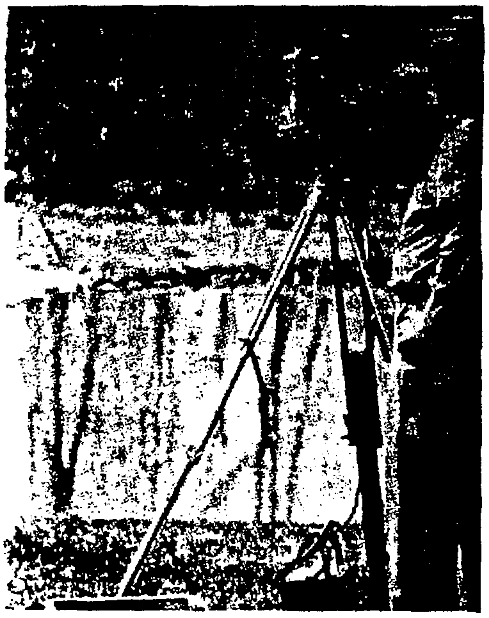
U.S. Department of Agriculture Soil Conservation Service. May 1974. Soil Survey of Sussex County Delaware.

State of Delaware. Proposed Freshwater Wetlands Act. June 1991. (Senate Bill 169, June 6, 1991, 136th General Assembly).

7.0 APPENDICES

APPENDIX A

MAP ACCURACY



National Mapping Program

Map Accuracy

U.S. Department of the Interior
Geological Survey
National Cartographic
Information Center

An inaccurate map is not a reliable map. "X" may mark the spot where the treasure is buried, but unless the seeker can locate "X" in relation to known landmarks or positions, the map is not very useful.

The U.S. Geological Survey publishes maps, orthophotomaps, and other products of high levels of accuracy. Dependability is vital, for example, to engineers, highway officials, and land-use planners who use the Survey's topographic maps as a basic planning tool.

As a result, the U.S. Geological Survey makes every effort to achieve a high level of accuracy in all of its published products. An important aim of its accuracy control program is to meet the U.S. National Map Accuracy Standards.

National Map Accuracy Standards

To find methods of insuring the accuracy of both location (the latitude and longitude of a point) and elevation (the altitude above sea level), the American Society of Photogrammetry — a scientific association of photogrammetrists who work with aerial photographs — set up a committee in 1937 to draft accuracy specifications. Sparked by this work, agencies of the Federal Government, including the Geological Survey, began their own inquiries and studies of map standards. In 1941 the U.S. Bureau of the Budget issued the "United States National Map Accuracy Standards," which applied to all Federal agencies that produced maps. The standards were revised several times, and the current version was issued in 1947. (This version is printed on the reverse side of the handout.)

As applied to the U.S. Geological Survey 7.5-minute quadrangle topographic map, the horizontal accuracy standard requires that the positions of 90 percent of all points tested will be accurate within 1/50th of an inch (0.05 centimeters) on the map. The vertical accuracy standard says that the elevations of 90 percent of all points tested should be correct within hal of the contour interval. On a map with a contour interval of 10 feet, therefore, the map will correctly place 90 percent of all points tested within 5 feet (1.5 meters) of the actual elevation.

Except for small-scale series, all maps produced by the U.S. Geological Survey carry the statement, "This map complies with National Map Accuracy Standards." Other exceptions involve areas covered by dense woodland or always obscured by fog or clouds; in those areas, aerial photography is unable to provide the detail needed for precise mapping. The Geological Survey tests enough of its maps, as described below, to make sure that th instruments and procedures the Survey uses are producing maps that meet the U.S. National Map Accuracy Standards.

Unavoidable Factual Errors

There are certain kinds of errors in mapmaking that are almost unavoidable. These have to do with factual rather than mathematical matters. The items most subject to errors are names and symbols of features, and the classifications of roads or woodlands.

Mapmakers cannot apply a numerical value to this kind of information; they must rely on local sources for their information. Sometimes the information is wrong. Sometimes names change or new names and features are added in an area. U.S. Geological Survey cartographers and editors check all maps thoroughly and, as a matter of professional pride, attempt to keep factual errors to a practical minimum.

How the Survey Maintains Map Accuracy

In 1958, the Survey began testing the accuracy of its maps systematically. At the outset of this program, the Survey tested at least 10 percent of the maps it produced. Today, because of technological advances in mapping techniques, only a small sampling of maps are tested as a method of controlling overall quality. It is rare for a 7.5-minute map to fail the test, but this happens on occasion.

In testing a map chosen at random, U.S. Geological Survey experts select 20 well-defined points; a typical point would be a crossroads. Field teams then are dispatched to the chosen sites to establish the positions of the 20 points, using the most sophisticated field surveying techniques. Vertical tests are run separately to determine precise elevations. The findings are reported back to the Survey, and the map is checked against the field survey results. If the map is accurate within the tolerances of the U.S. National Map Accuracy Standards, it receives certification and is published with the statement that it complies with those standards.

By such rigorous testing of some of its maps the Survey is able to determine that its general procedures for collecting map information are working well enough to assure a high level of map accuracy.

United States National Map Accuracy Standards

With a view to the utmost economy and expedition in producing maps which fulfill not only the broad needs for standard or principal maps, but also the reasonable particular needs of individual agencies, standards of accuracy for published maps are defined as follows:

1. Horizontal accuracy. For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc. In general what is well-defined will also be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles, would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch. Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.

2. Vertical accuracy, as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

3. The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing agency, which shall also determine which of its maps are to be tested, and the extent of such testing.

4. Published maps meeting these accuracy requirements shall note this fact in their legends, as follows: "This map complies with National Map Accuracy Standards."

5. Published maps whose errors exceed those aforestated shall omit from their legends all mention of standard accuracy.

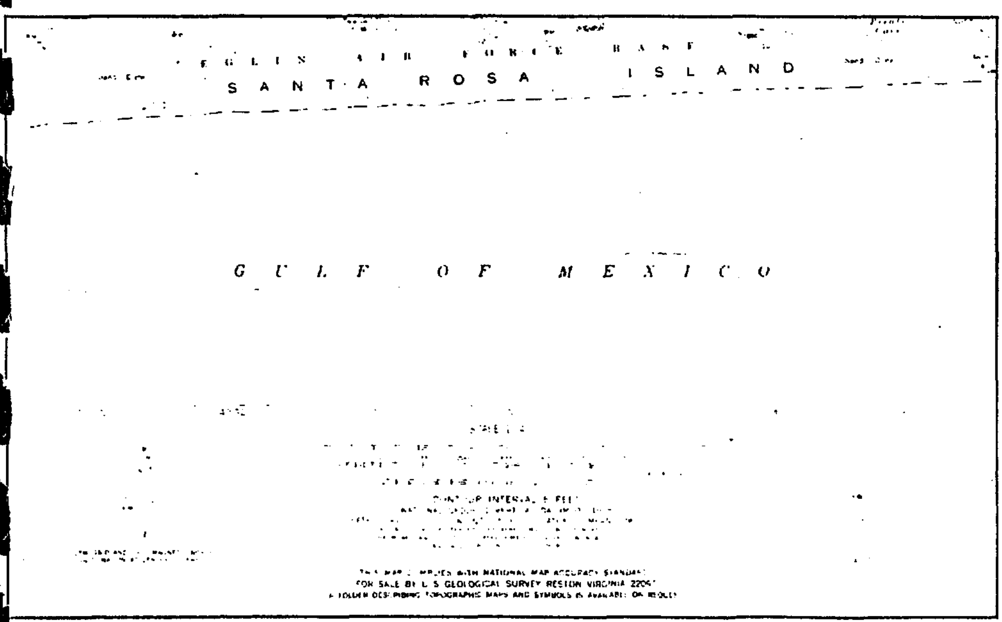
6. When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

7. To facilitate ready interchange and use of basic information for map construction among all Federal mapmaking agencies, manuscript maps and published maps, wherever economically feasible and consistent with the use to which the map is to be put, shall conform to latitude and longitude boundaries, being 15 minutes of latitude and longitude, or 7 ½ minutes, or 3 ¾ minutes in size.

How To Obtain More Information

If you want to know more about this subject or more about maps, please send your inquiry with your name, address, organizational affiliation, and telephone number to:

National Cartographic Information Center
U.S. Geological Survey
507 National Center
Reston, Virginia 22092
Telephone: 703-860-6045



Map Accuracy Statement on U.S. Geological Survey maps

or contact the following office:

APPENDIX B

FIELD DATA FORMS

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw/Giese Date: 4.15.91
Project/Site: Clayton - 3 State: Del County: NEW CASTLE
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Sweetgum			11.		
2. Tulip poplar			12.		
3. May apple			13.		
4. Strawberry bush			14.		
5. Sweetbay magnolia			15.		
6. Skunk cabbage			16.		
7. cinnamon fern			17.		
8. Pepper-bush			18.		
9. Multiflora rose			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale: ______

SOILS

Series/phase: Fallsington loam (Fs) Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ✓ No ____ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ✓ No ____
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: ______ Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ____ No ____
Rationale: ______

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: ______
Is the soil saturated? Yes X No ____
Depth to free-standing water in pit/soil probe hole: ______
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: SUFFICIENT SATURATION

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: ______

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw/Giese Date: 4.15 91
Project/Site: Clayton - 7 State: Del County: NEW CASTLE
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Pepper bush			11.		
2. Sweetbay Magnolia			12.		
3. river birch			13.		
4. Tulip poplar			14.		
5. wood anenome			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale: ______

SOILS

Series/phase: Fallsington loam (Fs) Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ✓ No ____ Undetermined ____
Is the soil a Histosol? Yes ____ No ____ Histic epipedon present? Yes ✓ No ____
Is the soil: Mottled? Yes ____ No ____ Gleyed? Yes ____ No ____
Matrix Color: ______ Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: ______

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: ______
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ______
List other field evidence of surface inundation or soil saturation.
HUMMOCKING, MOSS COLLARS, BUTTRESSED TRUNKS
Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: ______

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: ______

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw / Giese Date: 4.15.91
Project/Site: Clayton - 9 State: Del County: NEW CASTLE
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Beech			11.		
* 2. Highbush Blueberry			12.		
3. Red Oak			13.		
4. Red Maple			14.		
5. Swamp Chestnut Oak			15.		
6. Sassafras			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC
Is the hydrophytic vegetation criterion met? Yes ____ No ✓
Rationale:

SOILS

Series/phase: Fallsington loam (Fs) Subgroup:[2]
Is the soil on the hydric soils list? Yes ✓ No ____ Undetermined
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ____ No ✓
Rationale: 4 CHROMA

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: N/A
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale:

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw/Giese Date: 4.16.91
Project/Site: Clayton - 14 State: Del County: NEW CASTLE
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ___ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ___ No ✓ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum		Dominant Plant Species	Indicator Status	Stratum
*	1. Highbush Blueberry				11.		
	2. Tulip poplar				12.		
	3. Southern Red Oak				13.		
	4. Sweetgum				14.		
	5. Red maple				15.		
	6. Swamp Chestnut Oak				16.		
Trace	7. Greenbriar				17.		
Trace	8. Strawberry Bush				18.		
Trace	9. Arrowwood				19.		
	10. Sweetbay magnolia				20.		

Percent of dominant species that are OBL, FACW, and/or FAC
Is the hydrophytic vegetation criterion met? Yes ___ No ___
Rationale:

SOILS

Series/phase: Fallsington sandy loam (Fa) Subgroup:[2]
Is the soil on the hydric soils list? Yes ✓ No ___ Undetermined ___
Is the soil a Histosol? Yes ___ No ✓ Histic epipedon present? Yes ✓ No ___
Is the soil: Mottled? Yes ___ No ___ Gleyed? Yes ___ No ___
Matrix Color: Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ___
Rationale:

HYDROLOGY

Is the ground surface inundated? Yes ✓ No ___ Surface water depth: 0-4 inches
Is the soil saturated? Yes ✓ No ___
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.
HUMMOCKING, BUTTRESSED TRUNKS
Is the wetland hydrology criterion met? Yes ✓ No ___
Rationale:

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ___
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw / Giese Date: 4.16.91
Project/Site: Clayton - 15 State: Del County: NEW CASTLE
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum		Dominant Plant Species	Indicator Status	Stratum
* 1.	Red maple			11.			
2.	Highbush blueberry			12.			
3.	Sweet gum			13.			
4.	Flowering Dogwood			14.			
5.	Maleberry			15.			
6.	Christmas fern			16.			
7.				17.			
8.				18.			
9.				19.			
10.				20.			

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale: ______

SOILS

Series/phase: Fallsington sandy loam (Fa) Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ✓ No ____ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: ______ Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: ______

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: N/A
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: ______

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: ______

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw / Giese Date: 4.17.91
Project/Site: Harrington - 1 State: Del County: KENT
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ___ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ___ No ✓ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
*1. Green Ash			11. Solomon seal		
understory *2. Ironwood			12. Arrowwood		
3. wood anenome			13. American Holly	trace	
4. may apple			14. Sweetbay magnolia		
5. cinnamon fern			15.		
6. netted chain fern			16.		
7. spice bush			17.		
8. elderberry			18.		
9. Red maple			19.		
10. Jack in the Pulpit			20.		

Percent of dominant species that are OBL, FACW, and/or FAC
Is the hydrophytic vegetation criterion met? Yes ✓ No ___
Rationale:

SOILS

Series/phase: Johnston silt loam (Jo) Subgroup:[2]
Is the soil on the hydric soils list? Yes ✓ No ___ Undetermined
Is the soil a Histosol? Yes ___ No ✓ Histic epipedon present? Yes ___ No ✓
Is the soil: Mottled? Yes ✓ No ___ Gleyed? Yes ___ No ✓
Matrix Color: Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ___
Rationale:

HYDROLOGY

Is the ground surface inundated? Yes ___ No ✓ Surface water depth:
Is the soil saturated? Yes ✓ No ___
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ___
Rationale:

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ___
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw / Giese Date: 4.17.91
Project/Site: Harrington - 2 State: Del County: KENT
Applicant/Owner: ________ Plant Community #/Name: ________
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ____ No ✓ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ✓ No ____ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum		Dominant Plant Species	Indicator Status	Stratum
1.	Yellow rocket			11.			
2.	common chickweed			12.			
3.	mouse ear "			13.			
4.	Butter cup			14.			
5.	Dandelion			15.			
6.	wild Onion			16.			
7.				17.			
8.				18.			
9.				19.			
10.				20.			

Percent of dominant species that are OBL, FACW, and/or FAC ________
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale: ________

SOILS (SaA)

Series/phase: Sassafras Sandy loam Subgroup:[2] ________
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 2 CHROMA Mottle Colors: ________
Other hydric soil indicators: ________
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: ________

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: ________
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: <18"
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: ________

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision: ________

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw / Giese Date: 4.17.91
Project/Site: Harrington - 7 State: Del County: KENT
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ___ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ✓ No ___ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Black Gum			11.		
2. Red Maple			12.		
3. Pin Oak			13.		
4.			14.		
5. numerous vines on trees			15.		
6. no understory			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC ___
Is the hydrophytic vegetation criterion met? Yes ___ No ___
Rationale:

SOILS

Series/phase: Fallsington loam (Fs) Subgroup:[2]
Is the soil on the hydric soils list? Yes ✓ No ___ Undetermined ___
Is the soil a Histosol? Yes ___ No ✓ Histic epipedon present? Yes ___ No ✓
Is the soil: Mottled? Yes ✓ No ___ Gleyed? Yes ✓ No ___
Matrix Color: 1 CHROMA Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ___
Rationale:

HYDROLOGY

Is the ground surface inundated? Yes ___ No ✓ Surface water depth:
Is the soil saturated? Yes ✓ No ___
Depth to free-standing water in pit/soil probe hole:
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ___
Rationale:

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ___
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Fraw Giese Date: 4-18-91
Project/Site: Cape Henlopen - 1 State: Del County: Sussex
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ____ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ____ No ✓ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. Pitch Pine			11.		
2. marsh elder			12.		
3. toadflax			13.		
4. Highbush Blueberry			14.		
5. Bayberry			15.		
6.			16.		
7.			17.		
8.			18.		
9.			19.		
10.			20.		

Percent of dominant species that are OBL, FACW, and/or FAC
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale:

SOILS

Series/phase: Coastal beach and dune land (Co) Subgroup:[2]
Is the soil on the hydric soils list? Yes ____ No ✓ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ____ No ✓
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ____ No ✓
Rationale: Mottling Below 18 inches

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ____ No ✓
Depth to free-standing water in pit/soil probe hole: N/A
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ____ No ✓
Rationale: TOO WELL DRAINED

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ____ No ✓
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Fraw / Giese Date: 4.18.91
Project/Site: Cape Henlopen - 4 State: Del County: SUSSEX
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ______ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ______ No ✓ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum		Dominant Plant Species	Indicator Status	Stratum
1.	Yellow-eyed Grass			11.			
2.	Sundew			12.			
3.	Juncus			13.			
4.	Panicum			14.			
5.	Pitch Pine on N Border			15.			
6.				16.			
7.				17.			
8.				18.			
9.				19.			
10.				20.			

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ______ No ______
Rationale: ______

SOILS (Co)

Series/phase: Coastal beach and dune land Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ______ No ✓ Undetermined ______
Is the soil a Histosol? Yes ______ No ✓ Histic epipedon present? Yes ______ No ✓
Is the soil: Mottled? Yes ✓ No ______ Gleyed? Yes ______ No ✓
Matrix Color: ______ Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ______ No ✓
Rationale: ______

HYDROLOGY

Is the ground surface inundated? Yes ______ No ✓ Surface water depth: ______
Is the soil saturated? Yes ✓ No ______
Depth to free-standing water in pit/soil probe hole: ______
List other field evidence of surface inundation or soil saturation.
PONDING AT SURFACE
Is the wetland hydrology criterion met? Yes ✓ No ______
Rationale: ______

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ______
Rationale for jurisdictional decision: ______

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw, Giese Date: 4.19.91
Project/Site: Whaleysville - 3 State: Del County: SUSSEX
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ✓ No ___ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ___ No ✓ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
understory *	1. Loblolly pine			11. Serviceberry		
*	2. Rhododendron			12.		
saplings {	3. Swamp Chestnut Oak			13.		
	4. red maple			14.		
	5. Partridgeberry			15.		
x	6. Sweet leaf			16.		
	7. Highbush Blueberry			17.		
	8. mtn Laurel			18.		
	9. Tulip poplar			19.		
	10. Amer. Holly			20.		

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ___ No ___
Rationale: ______

SOILS

Series/phase: Pocomoke sandy loam (Pm) Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ✓ No ___ Undetermined ___
Is the soil a Histosol? Yes ___ No ✓ Histic epipedon present? Yes ___ No ✓
Is the soil: Mottled? Yes ✓ No ___ Gleyed? Yes ___ No ✓
Matrix Color: 4 to 5 CHROMA Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ___ No ✓
Rationale: CHROMA

HYDROLOGY

Is the ground surface inundated? Yes ___ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ___ No ✓
Depth to free-standing water in pit/soil probe hole: N/A
List other field evidence of surface inundation or soil saturation.
NONE
Is the wetland hydrology criterion met? Yes ___ No ✓
Rationale: ______

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ___ No ✓
Rationale for jurisdictional decision: ______

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw Giese Date: 4.19.91
Project/Site: Whaleysville - 8 State: Del County: SUSSEX
Applicant/Owner: Plant Community #/Name:
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ____ No ✓ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ✓ No ____ (If yes, explain on back)

VEGETATION

	Dominant Plant Species	Indicator Status	Stratum		Dominant Plant Species	Indicator Status	Stratum
* 1.	Bald Cypress			11.			
* 2.	Poison ivy - not viney	stems 0-2'		12.			
3.	netted chain fern			13.			
4.	Nettle			14.			
5.	elder-berry			15.			
6.	red maple			16.			
7.	Swamp cottonwood			17.			
8.				18.			
9.				19.			
10.				20.			

Percent of dominant species that are OBL, FACW, and/or FAC ____
Is the hydrophytic vegetation criterion met? Yes ____ No ____
Rationale:

SOILS

Series/phase: Pocomoke sandy loam (Pm) Subgroup:[2]
Is the soil on the hydric soils list? Yes ✓ No ____ Undetermined ____
Is the soil a Histosol? Yes ____ No ✓ Histic epipedon present? Yes ✓ No ____
Is the soil: Mottled? Yes ✓ No ____ Gleyed? Yes ____ No ✓
Matrix Color: 2 CHROMA Mottle Colors:
Other hydric soil indicators:
Is the hydric soil criterion met? Yes ✓ No ____
Rationale: CHROMA & MOTTLING

HYDROLOGY

Is the ground surface inundated? Yes ____ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ✓ No ____
Depth to free-standing water in pit/soil probe hole: ABOUT 12 INCHES
List other field evidence of surface inundation or soil saturation.
HUMMOCKING
Is the wetland hydrology criterion met? Yes ✓ No ____
Rationale: BARELY MEETS SATURATION CRITERIA

JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ____
Rationale for jurisdictional decision:

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

DATA FORM
ROUTINE ONSITE DETERMINATION METHOD[1]

Field Investigator(s): Straw/Giese Date: 4.19.91
Project/Site: Whaleysville - II State: Del County: SUSSEX
Applicant/Owner: ______ Plant Community #/Name: ______
Note: If a more detailed site description is necessary, use the back of data form or a field notebook.

Do normal environmental conditions exist at the plant community?
Yes ______ No ______ (If no, explain on back)
Has the vegetation, soils, and/or hydrology been significantly disturbed?
Yes ______ No ______ (If yes, explain on back)

VEGETATION

Dominant Plant Species	Indicator Status	Stratum	Dominant Plant Species	Indicator Status	Stratum
1. loblolly			11.		
2. Sweetgum (saplings)			12.		
3. sweet leaf			13.		
4. steeple bush			14.		
5. High bush Blueberry			15.		
6. Round headed Bush clover			16.		
7. St. John's wort			17.		
8. Broom sedge			18.		
9. Hercules club			19.		
10. multiflora rose			20.		

trace

Percent of dominant species that are OBL, FACW, and/or FAC ______
Is the hydrophytic vegetation criterion met? Yes ______ No ______
Rationale: ______

SOILS

Series/phase: Pocomoke sandy loam (Pm) Subgroup:[2] ______
Is the soil on the hydric soils list? Yes ✓ No ______ Undetermined ______
Is the soil a Histosol? Yes ______ No ✓ Histic epipedon present? Yes ______ No ✓
Is the soil: Mottled? Yes ✓ No ______ Gleyed? Yes ______ No ✓
Matrix Color: 2 CHROMA Mottle Colors: ______
Other hydric soil indicators: ______
Is the hydric soil criterion met? Yes ✓ No ______
Rationale: CHROMA + MOTTLES

HYDROLOGY

Is the ground surface inundated? Yes ______ No ✓ Surface water depth: N/A
Is the soil saturated? Yes ✓ No ______
Depth to free-standing water in pit/soil probe hole: AT ABOUT 15 INCHES
List other field evidence of surface inundation or soil saturation.

Is the wetland hydrology criterion met? Yes ✓ No ______
Rationale: SATURATION

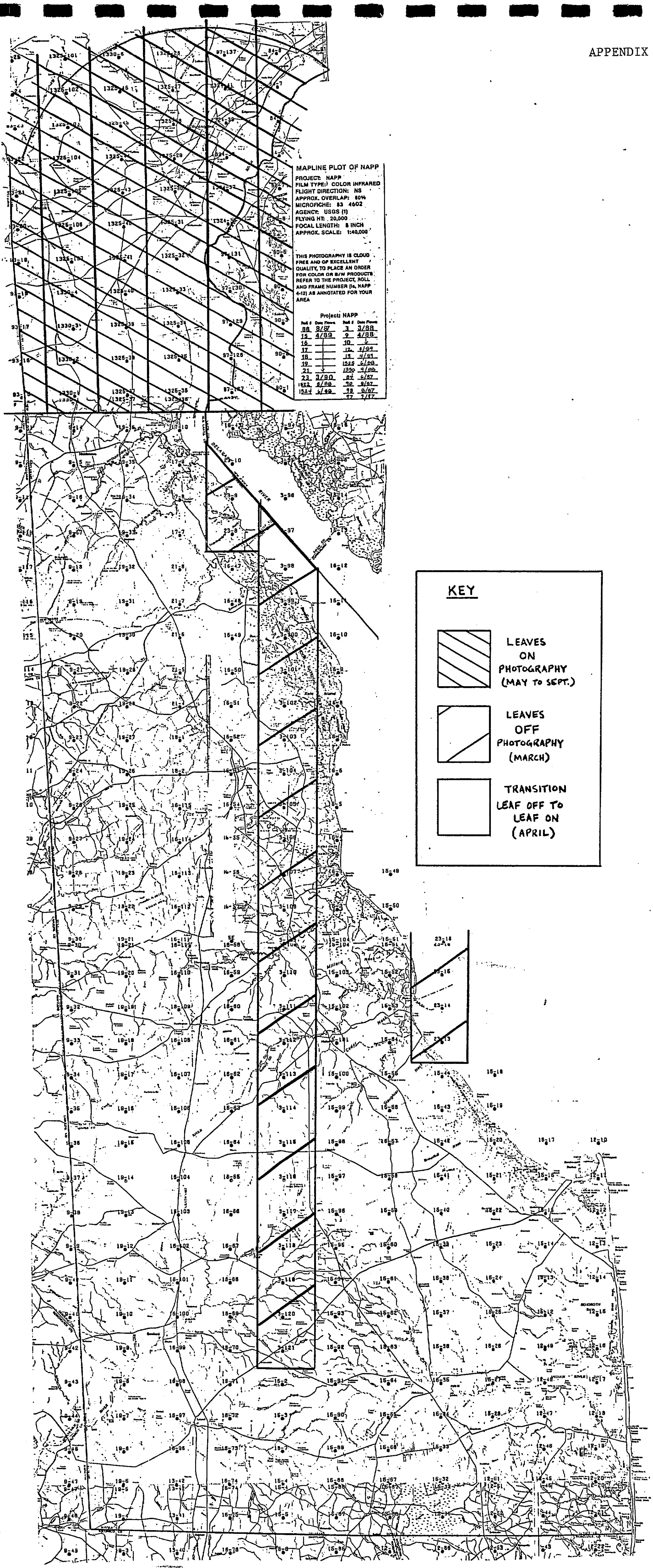
JURISDICTIONAL DETERMINATION AND RATIONALE

Is the plant community a wetland? Yes ✓ No ______
Rationale for jurisdictional decision: BORDERLINE CASE

[1] This data form can be used for the Hydric Soil Assessment Procedure and the Plant Community Assessment Procedure.
[2] Classification according to "Soil Taxonomy."

APPENDIX C

NAPP COVERAGE OF DELAWARE



NAPP COVERAGE OF DELAWARE

Prepared by Greenhorne & O'Mara, Inc. July 1991

GREENHORNE & O'MARA, INC.
9001 EDMONSTON ROAD, GREENBELT, MARYLAND 20770
(301) 982-2800

APPENDIX D1

SIMPLE VS. ORTHO RECTIFICATION

APPENDIX D1
Simple vs. Ortho Rectification

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Assawoman Bay, DE	S	S	S	NA	S	S	S	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bennets Pier, DE	NA	NA	NA	NA	NA	NA	NA	NA	S	NA	NA	NA	S	S	NA	NA
Bethany Beach, DE	S	S	S	NA	S	S	S	NA	S	S	S	NA	S	S	S	NA
Bombay Hook, DE-NJ	S	NA	NA	NA	S	S	NA	NA	S	S	S	NA	S	S	S	S
Burrsville, MD-DE	S	S	S	S	S	S	S	S	O	S	S	S	S	S	S	S
Cape Henlopen, DE	NA	NA	NA	NA	NA	NA	NA	NA	O	O	NA	NA	S	O	NA	NA
Cecilton, DE	NA	NA	NA	O	NA	NA	NA	O	O	O	O	O	O	O	O	O
Clayton, DE	O	O	O	O	O	S	O	O	S	O	O	O	S	O	S	O
Delware City,DE-NJ	O	S	NA	NA	O	O	NA	NA	O	S	NA	NA	O	A	A	NA
Delmar, DE	S	S	S	S	S	S	S	O	NA	NA	NA	NA	NA	NA	NA	NA
Dover, DE	O	O	S	S	S	O	O	S	O	S	O	O	S	O	O	O
Elkton, DE	NA	NA	O	O	NA	NA	O	S	NA	NA	O	O	NA	NA	NA	O

Key:

S - Simple rectification is sufficient
O - Ortho rectification is required
NA - Not applicable, no part of the 1/16th quad is located in the State of Delaware

APPENDIX D1
Simple vs. Ortho Rectification

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ellendale, DE	S	O	O	O	S	S	O	S	S	S	S	O	S	S	S	S
Fairmount, DE	O	O	S	O	O	O	O	O	O	O	O	O	O	S	S	S
Frankford, DE	O	S	S	S	O	S	S	S	O	O	S	S	S	O	S	S
Frederica, DE	O	S	S	S	O	S	S	S	O	O	S	S	O	O	O	S
Georgetown, DE	S	S	S	S	O	S	S	S	S	S	S	S	S	S	S	S
Greenwood, DE	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Harbeson, DE	S	S	S	O	S	S	S	S	S	S	S	S	S	O	S	S
Harrington, DE	S	O	O	O	S	S	O	O	S	S	S	S	S	S	S	S
Hebron, DE	NA	S	S	S	NA	S	S	S	NA	NA	NA	NA	NA	NA	NA	NA
Hickman, DE	S	S	S	S	S	O	O	S	S	S	O	S	O	O	S	S
Kenneth Square, DE	NA	NA	NA	NA	NA	NA	O	O	O	O	O	O	O	O	O	O
Kenton, DE-MD	O	S	O	O	S	S	O	S	S	S	S	O	S	S	S	S
Laurel, DE	O	S	S	S	O	O	O	S	O	O	O	S	S	S	S	O
Lewes, DE	S	NA	NA	NA	S	S	NA	NA	S	S	S	S	O	O	O	O
Little Creek, DE	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	NA
Marcus Hook,PA-DE-NJ	NA	NA	NA	NA	O	O	S	NA	O	O	S	NA	O	NA	NA	NA

Key:

S - Simple rectification is sufficient
O - Ortho rectification is required
NA - Not applicable, no part of the 1/16th quad is located in the State of Delaware

APPENDIX D1
Simple vs. Ortho Rectification

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Marydel,DE-MD	O	S	S	S	O	S	S	S	O	O	S	S	S	S	S	S
Middletown, DE	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Milford, DE	O	O	O	O	O	O	O	S	O	O	O	O	O	O	O	O
Millsboro, DE	S	O	O	O	S	O	S	S	S	S	S	S	S	S	S	S
Milton, DE	O	O	S	S	O	S	S	S	S	O	O	S	O	O	O	O
Mispillion River, DE	S	S	NA	NA	S	S	S	NA	O	S	S	NA	O	S	S	S
Newark East, DE	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Newark West, DE	NA	NA	O	O	NA	NA	O	O	NA	NA	O	O	NA	NA	O	O
Pittsville, DE	S	S	S	S	S	S	S	S	NA	NA	NA	NA	NA	NA	NA	NA
Rehobeth Beach, DE	S	S	NA	NA	S	S	NA	NA	S	S	NA	NA	S	S	NA	NA
Saint Georges,DE	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Seaford East, DE	S	O	O	S	S	O	O	O	S	O	O	O	O	O	O	O
Seaford West, DE	NA	S	S	S	NA	S	S	O	NA	S	O	S	NA	S	O	O
Selbyville, DE	S	S	S	S	O	O	S	O	NA	NA	NA	NA	NA	NA	NA	NA
Sharptown, DE	NA	O	O	S	NA	O	O	S	NA	O	O	O	NA	O	S	O
Smyrna, DE	O	S	S	S	O	O	S	S	O	O	S	S	O	O	S	S

Key:

S - Simple rectification is sufficient
O - Ortho rectification is required
NA - Not applicable, no part of the 1/16th quad is located in the State of Delaware

APPENDIX D1
Simple vs. Ortho Rectification

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Taylor'sBridge,DE-NJ	O	S	NA	NA	S	S	NA	NA	O	S	S	NA	O	S	S	S
Trap Pond, DE	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Whaleysville, DE	S	S	S	S	S	S	S	S	NA	NA	NA	NA	NA	NA	NA	NA
Wilmington N, DE-PA	O	O	O	O	O	O	O	O	NA	O	O	O	NA	O	O	O
Wilmington S, DE-NJ	O	O	O	O	O	O	O	S	O	O	O	NA	O	S	NA	NA
Wyoming, DE	O	O	O	O	S	O	O	O	S	S	O	O	S	S	O	O

Key:

S - Simple rectification is sufficient
O - Ortho rectification is required
NA - Not applicable, no part of the 1/16th quad is located in the State of Delaware

APPENDIX D2

EXPECTED GROUND DISPLACEMENTS

APPENDIX D2
Expected Ground Displacements (in feet)
When Simple Rectification is used instead of Ortho Rectification

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Assawoman Bay, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bennets Pier, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bethany Beach, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bombay Hook, DE-NJ	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Burrsville, MD-DE	X	X	X	X	X	X	X	X	25	X	X	X	X	X	X	X
Cape Henlopen, DE	X	X	X	X	X	X	X	X	20	20	X	X	X	43	X	X
Cecilton, DE	X	X	X	50	X	X	X	38	53	50	50	31	56	42	42	43
Clayton, DE	25	41	50	41	25	X	25	41	X	25	33	33	X	25	X	25
Delware City,DE-NJ	25	X	X	X	25	25	X	X	44	X	X	X	41	X	X	X
Delmar, DE	X	X	X	X	X	X	X	20	X	X	X	X	X	X	X	X
Dover, DE	36	33	X	X	X	25	25	X	25	X	36	20	X	25	25	25
Elkton, DE	X	X	173	33	X	X	50	X	X	X	33	33	X	X	X	33
Ellendale, DE	X	17	26	34	X	X	23	X	X	X	X	18	X	X	X	X
Fairmount, DE	20	24	X	20	20	32	20	24	20	20	24	24	20	X	X	X
Frankford, DE	20	X	X	X	20	X	X	X	24	20	X	X	X	20	X	X
Frederica, DE	22	X	X	X	29	X	X	X	25	28	X	X	28	17	17	X

<u>Key</u>:
X - 1/16th quad is either not within the state or is listed in Appendix D1 under simple rectification.

APPENDIX D2
Expected Ground Displacements (in feet)

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Georgetown, DE	X	X	X	X	19	X	X	X	X	X	X	X	X	X	X	X
Greenwood, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Harbeson, DE	X	X	X	25	X	X	X	X	X	X	X	X	X	18	X	X
Harrington, DE	X	25	36	38	X	X	25	36	X	X	X	X	X	X	X	X
Hebron, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hickman, DE	X	X	X	X	X	22	25	X	X	X	17	X	25	25	X	X
Kenneth Square, DE	X	X	X	X	X	X	212	191	174	168	232	241	172	166	207	249
Kenton, DE-MD	25	X	33	36	X	X	25	X	X	X	X	25	X	X	X	X
Laurel, DE	33	X	X	X	32	29	22	X	22	20	25	X	X	X	X	17
Lewes, DE	X	X	X	X	X	X	X	X	X	X	X	X	20	20	20	20
Little Creek, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Marcus Hook,PA-DE-NJ	X	X	X	X	224	158	X	X	266	133	X	X	166	X	X	X
Marydel,DE-MD	23	X	X	X	25	X	X	X	35	25	X	X	X	X	X	X
Middletown, DE	25	50	40	41	27	46	50	41	33	50	50	50	51	50	41	41
Milford, DE	25	22	17	22	33	25	22	X	28	39	26	22	34	22	27	26

Key:
X - 1/16th quad is either not within the state or is listed in Appendix D1 under simple rectification.

APPENDIX D2
Expected Ground Displacements (in feet)

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Millsboro, DE	X	24	20	23	X	19	X	X	X	X	X	X	X	X	X	X
Milton, DE	25	18	X	X	21	X	X	X	X	25	17	X	25	29	25	17
Mispillion River, DE	X	X	X	X	X	X	X	X	19	X	X	X	7	X	X	X
Newark East, DE	190	207	207	183	241	224	108	58	58	47	75	69	224	52	62	60
Newark West, DE	X	X	2323	199	X	X	149	199	X	X	116	100	X	X	116	183
Pittsville, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rehobeth Beach, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Saint Georges,DE	33	41	52	51	33	42	59	58	58	58	41	41	36	44	51	38
Seaford East, DE	X	17	19	X	X	19	32	22	X	20	29	21	20	26	27	26
Seaford West, DE	X	X	X	X	X	X	X	17	X	X	17	X	X	X	27	21
Selbyville, DE	X	X	X	X	21	29	X	21	X	X	X	X	X	X	X	X
Sharptown, DE	X	18	27	X	X	18	21	X	X	20	22	25	X	25	X	17
Smyrna, DE	43	X	X	X	33	19	X	X	29	34	X	X	27	33	X	X
Taylor'sBridge,DE-NJ	7	X	X	X	X	X	X	X	25	X	X	X	39	X	X	X

Key:
X - 1/16th quad is either not within the state or is listed in Appendix D1 under simple rectification.

APPENDIX D2
Expected Ground Displacements (in feet)

Quad Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Trap Pond, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Whaleysville, DE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wilmington N, DE-PA	199	232	149	158	241	216	199	124	X	232	108	149	X	207	249	216
Wilmington S, DE-NJ	102	174	149	27	50	59	65	X	66	60	25	X	41	X	X	X
Wyoming, DE	25	26	25	25	X	26	27	27	X	X	33	25	X	X	25	33

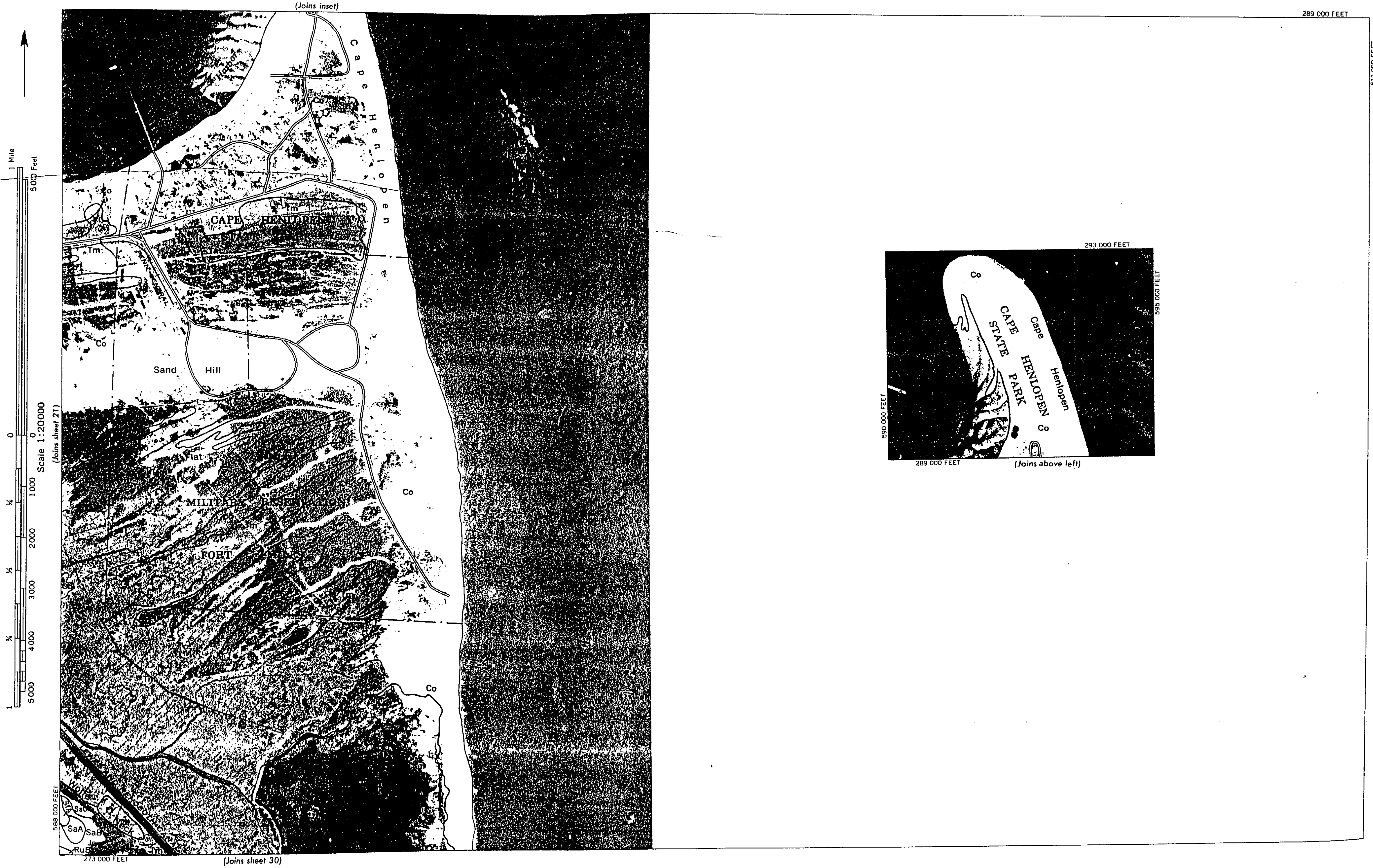
Key:
X - 1/16th quad is either not within the state or is listed in Appendix D1 under simple rectification.

APPENDIX E

SOILS MAPS

21

CAPE HENLOPEN

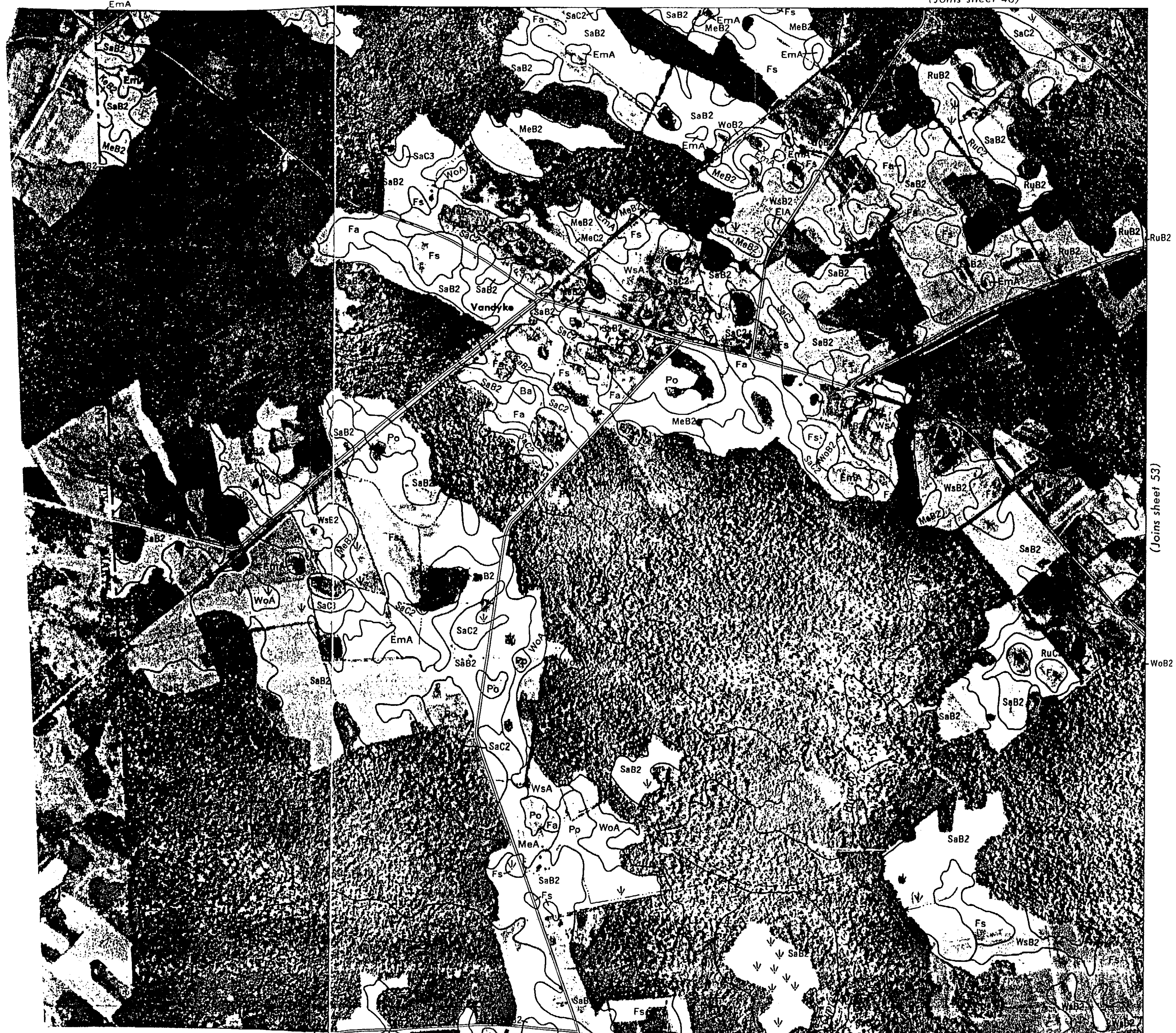


CAPE HENLOPEN

N

NEW CASTLE COUNTY, DELAWARE — SHEET NUMBER 52

(Joins sheet 48)



(Joins sheet 53)

0 ½ 1 Mile

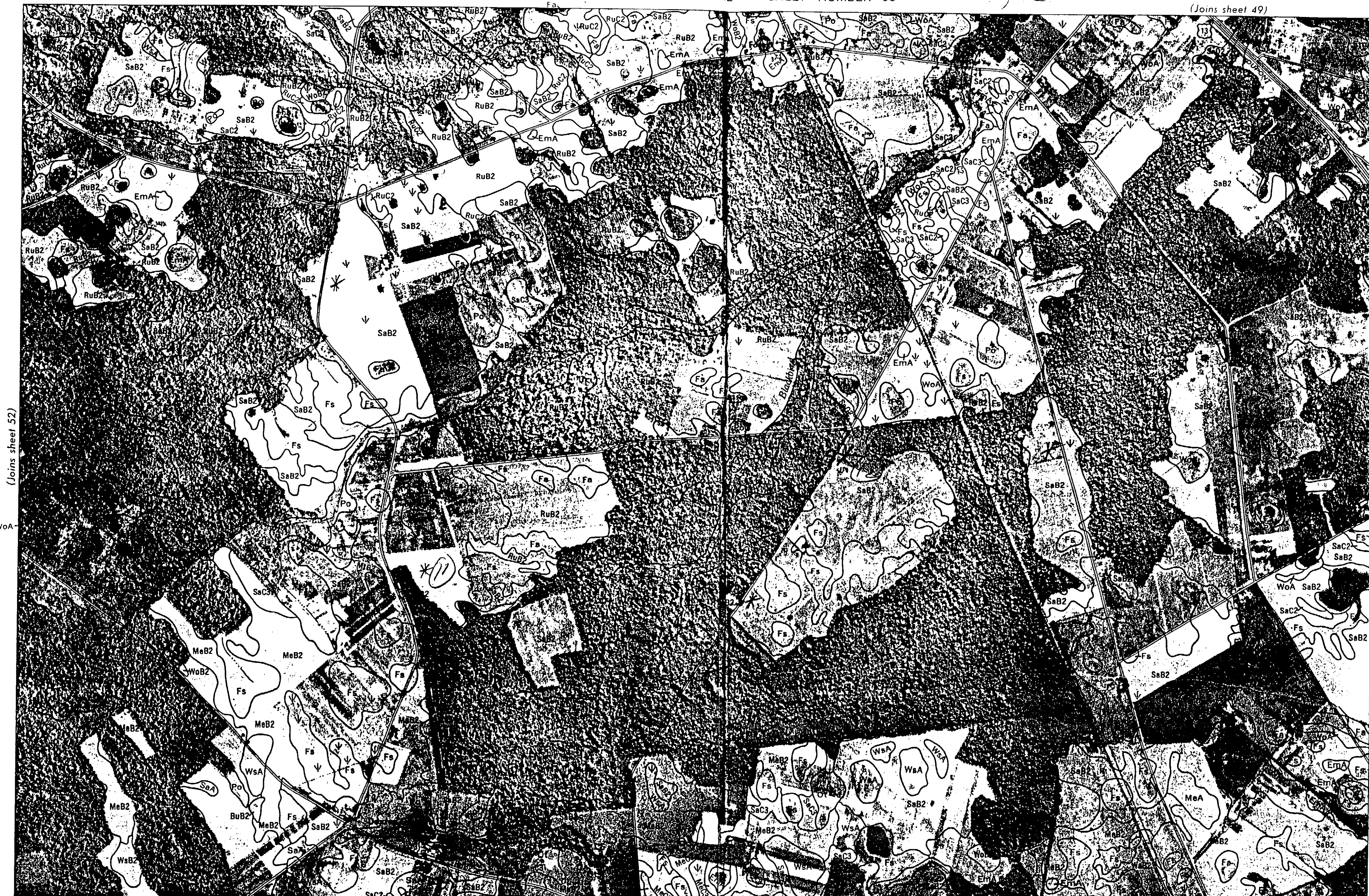
Scale 1:15 840

0 5000 Feet

(Joins sheet 56)

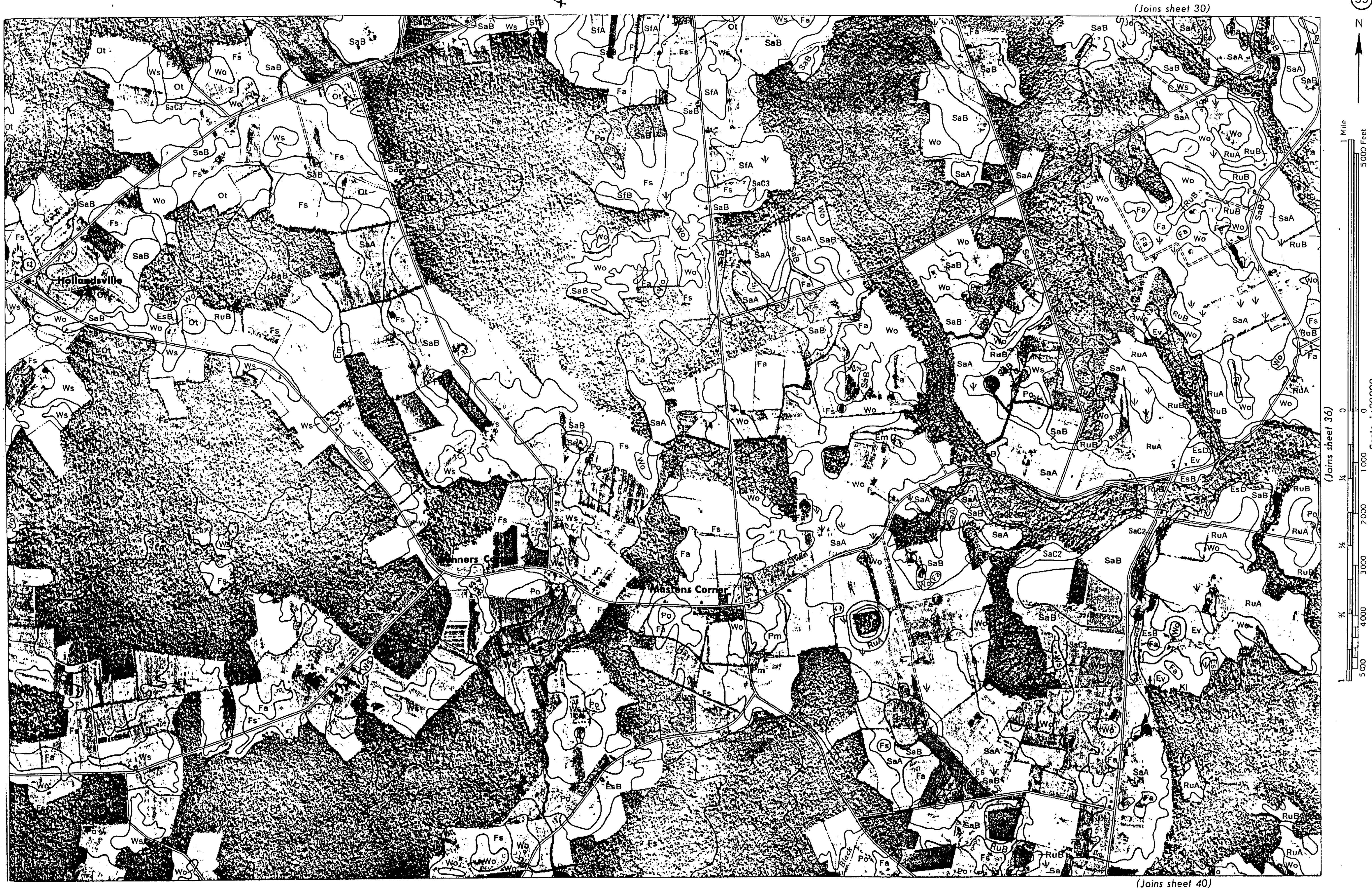
CLAYTON

NEW CASTLE COUNTY, DELAWARE — SHEET NUMBER 53



0 ½ 1 Mile Scale 1:15 840 0 5000 Feet

CLAYTON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Hollandsville
Mastens Corner
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1 Mile
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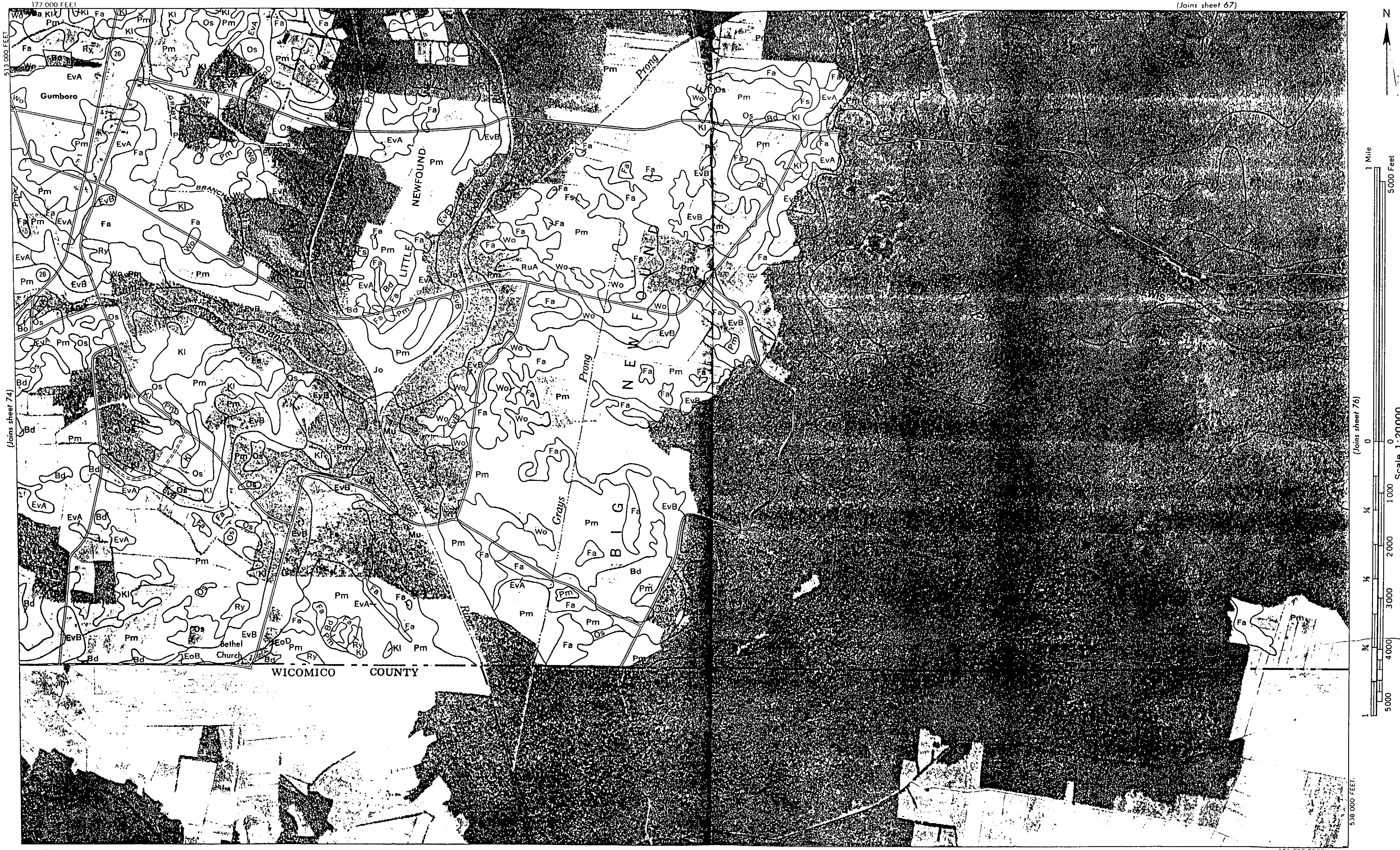
¼
½
¾
1

HARRINGTON



This map is one of a set compiled in 1971 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the Delaware Agricultural Experiment Station. Photobase from 1970 aerial photography. Positions of grid lines are approximate and based on the Delaware coordinate system.

WHALEYSVILLE